Aeronautical Engineering Review

JUNE, 1954

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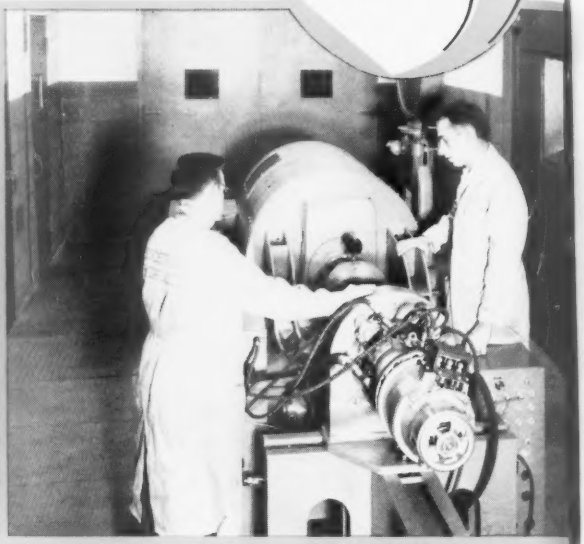
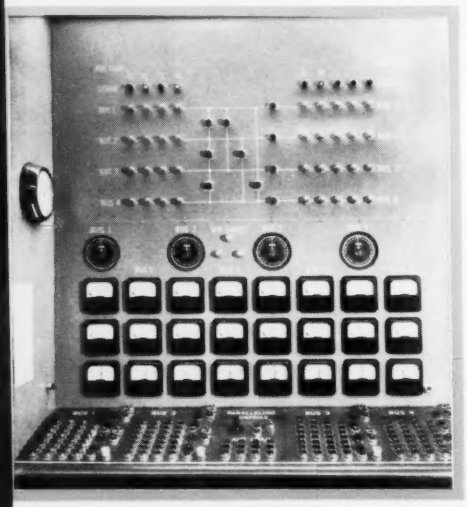


Increased number of test stands permits simultaneous scheduling of experimental work and production testing. Scope of work necessitated installation of synchronous motors and dynamometers up to 200 hp.



Master panel makes possible visual, accurate, remote control. The operator can parallel simultaneously the alternators driven by any four drives or any four pairs of drives.

14,700 square feet of floor space houses the expanded department, said by aircraft authorities to be the most complete constant speed drive testing facility in the world.

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CONSTANT SPEED DRIVES • AIRCRAFT ACCESSORIES

Aeronautical Engineering REVIEW

Vol. 13—No. 6 June, 1954

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Cover—This convertiplane, the XV-1, is the first military aircraft of this type ever developed in the United States and is the first convertiplane in the world to utilize the principle of pressure jets and high-disc loading. The aircraft is the joint development of the USAF's Air Research and Development Command, the U.S. Army's Transportation Corps, and McDonnell Aircraft Corporation. An extensive research program leading to its first flight includes ground testing, instrumentation for the development of flight-test data, and preflight test work. A full-scale model of the XV-1 has been placed in a wind tunnel to test aerodynamic characteristics.

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I.A.S. News Notes

June 1954

MINTA MARTIN AERONAUTICAL FUND TO AID STUDENTS

In an action approved by Glenn L. Martin and the Supreme Court of New York State, the Council of the Institute of the Aeronautical Sciences has redistributed the assets of the original Minta Martin Aeronautical Endowment Fund and established what will be known in the future as the Minta Martin Aeronautical Student Fund of the Institute. The income from this capital fund of $250,000 will be used in support of IAS Student Branch activities and to provide financial aid for lecturers, student competitions, the distribution of scientific information, etc. An Advisory Board, consisting of Mr. Martin, T. P. Wright, and the President and Director of the Institute, has been appointed to approve the administration of the Fund's earnings.

In 1942, Glenn L. Martin established the original Fund in honor of his mother for the expressed purpose of setting up certain aeronautical laboratories at the Guggenheim-donated property at Sands Point, L. I. Subsequent events made it impractical to complete this project, and the invested Fund of $500,000 was held pending some future suitable disposition.

That disposition has now been made and the total fund distributed in accordance with the wishes of Mr. Martin and the Institute Council. In addition to the $250,000 provided for the Minta Martin Aeronautical Student Fund, the assets of the original endowment have been distributed as follows:

$50,000 -- Jerome C. Hunsaker Professorship of Aeronautics, Massachusetts Institute of Technology, to provide for the Minta Martin Aeronautical Lectures.

$75,000 -- Washington College, Chestertown, Md., to assist in the completion of the Minta Martin Women's Dormitory.

$339,215 -- University of Maryland, to augment the Minta Martin Aeronautical Research Foundation of the Glenn L. Martin Institute of Technology.

Mr. Martin approved a plan for The Glenn L. Martin Company to donate $1,700,000 to the University of Maryland in 1944 and an additional $800,000 for 1946, making a total of $2,500,000 available to establish The Glenn L. Martin Institute of Technology, with several additional millions being furnished by the State of Maryland for the completion of the plant. The facilities include a wind tunnel and a fine aeronautical school as well as all the technological arts. The establishment of the Minta Martin Aeronautical Student Fund of the IAS creates another instrument through which the ideals and wishes of Glenn Martin and his mother will benefit aeronautical students all over the country for years to come.

Further information on the Student Fund activities will be announced shortly after a program has been worked out.

* * * * * * * *

I.A.S. News Notes (con't.)

NEW IAS CORPORATE MEMBER

Stanley Aviation Corporation, Buffalo Municipal Airport, Buffalo, New York

* * * * * * *

NECROLOGY

Major General Oliver P. Echols, USAF, (Ret.), FIAS, President, Northrop Aircraft, Inc., May 15.
Herbert Olden, MIAS, Managing Editor of Aviation Age, May 3.

* * * * * * *

NATIONAL MEETINGS CALENDAR

June 21-24 Annual Summer Meeting, IAS Building, 7660 Beverly Blvd., Los Angeles, California
Aug. 9-11 Turbine Powered Air Transportation Meeting, Seattle, Wash.
Dec. 17 Eighteenth Wright Brothers Lecture, Washington, D. C.

* * * * * * *

CALENDAR OF SECTION MEETINGS

June 10--Los Angeles Section: IAS Building. Specialist Meeting, 7:30 p.m. "Extension of Power Spectro Methods of Generalized Harmonic Analysis and Application to Aircraft Problems" by Bernard Mazelsky, Lockheed Aircraft Corporation.

June 10--San Diego Section: IAS Building. Technical Meeting, 7:45 p. m. "Sound Suppression in Aircraft Test Installations" by R. J. Koenig, Chief Technical Engineer, Kittell-Lacy, Inc.

June 12--Hampton Roads Section: Field trip to Norfolk Naval Base, Va. Dockside inspection of U.S.S. "Coral Sea" scheduled.

June 16--Seattle Section: Sand Point Naval Air Station, Washington. Social Hour, 6:00 p.m.; Dinner, 7:00 p.m.; Meeting, 8:00 p.m. "Aircraft Turbine Engines" by D. J. Downey, Power Plant Staff, Boeing Aircraft Company.

June 25--San Diego Section: IAS Building. Social Hour, 6:30 p.m.; Dinner, 7:00 p.m. Speaker, Abe Silverstein, Lewis Flight Propulsion Laboratory, NACA. Title of talk unknown at press time. (Date of this Dinner Meeting subject to change.)

June 25--Texas Section: Officers Club, Naval Air Station, Dallas, Social and Dance, 7:45 p.m.

* * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

Ninth Annual Flight Propulsion Meeting

Dr. D. P. Barnard, Deputy Assistant Secretary of Defense, Discusses Research and Development Program at Cleveland

Dr. D. P. Barnard

"THESE GATHERINGS are valuable for the interchange of information and ideas on the firing line of research and development." With this opening remark, Dr. Daniel P. Barnard, Deputy Assistant Secretary of Defense for Research and Development, addressed some interesting "observations, as a newcomer to the Washington scene," to a large dinner audience of Institute members at Cleveland on March 12.

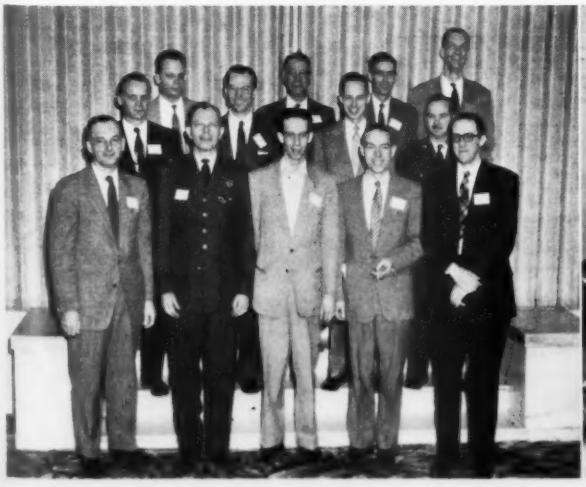
The occasion marked the close of the Institute's Ninth Annual Flight Propulsion Meeting and climaxed a day of highly successful, security-closed technical sessions attended by nearly 600 persons.

After outlining the problems confronting the nation with regard to an adequate continental defense system, Dr. Barnard continued: "With such an audience as this one, it is hardly necessary to dwell on the need for military research and development. Undoubtedly you would all agree that an active program is mandatory. However, there would be considerable differences of opinion as to the amount necessary. There would also be many ideas about the management and conduct of the program.

"Let us look at the current research and development program. As you well know, research and development is primarily scientific and technical man power; it is specialized laboratories; it is thousands of individual tasks. Our military research and development program is too vast in scope to discuss it in terms of the individual projects, or the skilled scientists, or the facilities. In dealing with this vast program we use 'dollars' as the common denominator.

"The recent Economic Report of the President to the Congress shows that total national expenditure for research and development is about 4 billion dollars from all sources. . . . About half the national total is being devoted to military programs, including, of course,

(*Left*) Technical Sessions' speakers and chairmen. (*Right*) Dinner in the ballroom of the Hotel Carter.



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"Now, while the defense effort needs all possible research and development, we cannot monopolize the nation's entire research and development capacity. We cannot impoverish the industrial and civilian economy that must, in the last analysis, support all the defense effort. It is doubtful that higher than present military research and development levels could be maintained without damage to the essential civilian economy. It is also doubtful that a much lower level of effort would be wise in the face of the threat to our national survival.

"Dollarwise we are now spending more money on military research and development than at any time before in our history. The direct expenditures will be about 1.3 billion dollars this fiscal year. These funds finance some 8,000 separate identifiable projects. Since modern war is total war, our range of interest is extremely broad. . . . For example, there is effort toward maintaining food flavors and nourishing values under conditions of very long storage; there are guided-missile systems such as NIKE. We have projects on specialized clothing for the tropics and the arctic, and we have supersonic interceptors. There are armored vests, and there are radars. In size these range from a few thousand dollars for research tasks to many millions each for the complex missile systems.

"During the years 1947 to 1950, the amount spent averaged about 500 million dollars annually; so the present level is about two and a half times that during the years just prior to the Korean war. . . .

"The new budget submitted to Congress for fiscal year 1955 reduces the research and development appropriation requests by about 7 per cent. Under the present world conditions, with little prospect for improvement, we must get substantially more defense value from this lower cost to the taxpayer. We believe that this can be done, and we plan to achieve it by more effective management of research and development through our new organizational structure."

Dr. Barnard continued his address with an interesting description of this new organizational structure in the Department of Defense and concluded by saying, "In peacetime, one important objective of the Defense establishment is to keep us out of war. Research and development must continuously provide the 'know-how' that will make this possible."

Arrangements for the Ninth Flight Propulsion Meeting were carried out, as usual, by the Cleveland-Akron Section of the Institute. All credit for the success of this meeting goes to the local members of the various program committees, the NACA, and the personnel of Air Procurement District of the USAF, who handled the security details.

The reception and displays, sponsored by local manufacturers of the Cleveland area, were additional and appreciated features of the meeting. Hosts for the reception included: American Steel and Wire Company, Cleveland Pneumatic Tool Company, Eaton Manufacturing Company, General Electric Company, General Tire & Rubber Company, The B. F. Goodrich Company, Goodyear Aircraft Company, Jack & Heintz, Inc., Romec Division of Lear Incorporated, Steel Improvement & Forge Company, and Thompson Products, Inc.

The informative and interesting displays set up in the Hotel Carter by eight of these companies are pictured on the opposite page.

Ryan Becomes IAS Corporate Member

Ryan Aeronautical Company, of San Diego, which was incorporated on June 5, 1931, has rejoined the Institute of the Aeronautical Sciences as a Corporate Member.

T. Claude Ryan, President and Founder of the company, first established a commercial aviation business in San Diego in the fall of 1922. Three years later, Ryan Airlines, Inc., began the first year-round regularly scheduled passenger service in the United States, operating between San Diego and Los Angeles. Within a short time, the company branched out into aircraft design and production and became the first volume manufacturer of monoplanes in this country. The most famous of the early Ryan planes is Charles A. Lindbergh's "Spirit of St. Louis," a modified Ryan Brougham.

In the mid-1930's, Ryan designed and manufactured the S-T, a low-wing metal trainer. By the late 1930's, Ryan began the manufacture of more than 1,000 aircraft of the S-T series for the U.S. Army Air Force, the U.S. Navy, and various foreign countries. Some 14,000 wartime pilots received their primary instruction in these Ryan trainers.

Just prior to World War II, Ryan began to produce a wide variety of specialized aeronautical products, including aircraft-engine exhaust systems and air-frame components.

About 1943, Ryan undertook the design and development of a new fighter that combined for the first time a reciprocating engine and a jet power plant. This aircraft, known as the FR-1 Fireball, went into volume production for the U.S. Navy.

After World War II, Ryan acquired all rights to the Navion, a four-place all-metal executive airplane. More than 1,000 Ryan Navions have been built for commercial use and for the U.S. Army Field Forces.

Currently, the Ryan Firebee jet-propelled pilotless target plane is in production, as are high-temperature components for jet, piston, and rocket engines, air-frame assemblies, external fuel tanks, and air-borne electronic components. The company is now working on a new jet aircraft of its own design.

Institute of Air Flight Structures' Advisory Council Formed

Grover Loening, IAS Fellow, Benefactor, and Founder Member, Aeronautical Consultant, has been appointed Chairman of the Advisory Council of the recently established Institute of Air Flight Structures by the Trustees of Columbia University.

Serving with Mr. Loening on the Council are: Preston R. Bassett, IAS Honorary Fellow and Founder Member, President of Sperry Gyroscope Company, Division of The Sperry Corporation; Dr. Hugh L. Dryden, IAS Honorary Fellow, Honorary Member, and Founder Member, Director of NACA; Major Lester D. Gardner, IAS Fellow, Benefactor, and Founder Member, Founder of the Institute of the Aeronautical Sciences; Harry F. Guggenheim, IAS Honorary Member, Member, Benefactor, and Founder Member, President of The Daniel and Florence Guggenheim Foundation; Roy A. Hunt, Chairman, Executive Committee, Aluminum Company of America; Francis S. Murphy, Chairman, Connecticut Aeronautics Commission; George B. Pegram, IAS Associate Fellow and Founder Member, Vice-President Emeritus and Special Advisor to the President, Columbia University; Leon H. Swirbul, President, Grumman Aircraft Engineering Corporation; and G. Edward Pendray, Senior Partner, Pendray and Company.

The Institute of Air Flight Structures, supported by the Guggenheim Foundation, will serve as a national education and research center for the study of air flight structures, particularly in the supersonic range of jet- and rocket-powered aircraft and guided missiles. It is now being organized within the Columbia University Engineering Center.

Nine IAS Corporate Members Back Procurement Course at Fordham University

An Aircraft Buyers' course, sponsored by nine Corporate Members of the Institute of the Aeronautical Sciences, was initiated last February at Fordham University. This is an intensive 3-

week course that studies the various problems associated with aircraft procurement. It was repeated five times during Fordham's past Spring Semester and will be continued during the 1954–1955 academic year.

Patterned after a similar one begun several years ago at the University of California at Los Angeles, the course follows the case-study method used by Harvard University's Graduate School of Business Administration. The cases employed in this seminar-type course are the same ones that form the basis of the UCLA course.

The nine IAS Corporate Members behind this Fordham University venture are: Bell Aircraft Corporation; Bendix Aviation Corporation; Fairchild Engine and Airplane Corporation; The Goodyear Tire & Rubber Company's Goodyear Aircraft Corporation; Grumman Aircraft Engineering Corporation; The Glenn L. Martin Company; Pratt & Whitney Aircraft Division of United Aircraft Corporation; Republic Aviation Corporation; and Thompson Products, Inc.

Norwich University Names Aviation Advisory Board

Norwich University, of Northfield, Vt., at which a Department of Aviation was recently established, has named an Aviation Advisory Board. This board acts in an advisory capacity in the development and programming of this new department.

Among those persons appointed to the Aviation Advisory Board are four IAS members. These are: Dr. Leslie A. Bryan, MIAS, Director, Institute of Aviation, University of Illinois; Joseph T. Geuting, Jr., AMIAS, Manager, Utility Airplane Council, Aircraft Industries Association of America, Inc.; Charles S. (Casey) Jones, AFIAS, President, Academy of Aeronautics; and Wayne W. Parrish, AMIAS, Editor and Publisher, American Aviation Publications, Inc.

SAE Wright Brothers Award

M. Zbyslaw Ciolkosz, AFIAS, and Donald N. Meyers, MIAS, of Piasecki Helicopter Corporation, are the recipients of the Society of Automotive Engineers' Wright Brothers Award for 1953. The presentation of this award was made to them at the SAE Aeronautic Meeting dinner on April 15. Each recipient received a bronze medal, a certificate, and an honorarium.

The award was presented to the Messrs. Ciolkosz and Meyers for their joint paper on "Matching the Characteristics of Helicopters and Shaft-Turbines." In this paper, which was delivered at the 1953 SAE Annual Meeting, the authors give evidence to show that the shaft-turbine is a superior helicopter power plant for many applications.

Mr. Ciolkosz is Chief Development Design Engineer for Piasecki's Preliminary Design Division. Mr. Meyers is Chief of that division.

International Geophysical Year Program; IAS Members Named to U.S. Committee

An International Geophysical Year program to gather geophysical data in synoptic form is now being planned for 1957 and 1958. Recognizing the global nature of geophysical phenomena, 28 nations had indicated by last April their intentions of participating in the IGY program.

This proposed international effort for 1957 and 1958 will surpass in scope, intensity, and geographical coverage the two previous projects of a similar type. (These earlier ones were held in 1882 and 1883 and in 1932 and 1933.) This forthcoming IGY program is scheduled to cover the Arctic and Antarctic regions as well as the major land and sea masses of the earth. In all, ten fields will be under study, viz.; solar activity, longitude and latitude, glaciology, oceanography, meteorology, geomagnetism, aurora and airglow, ionospheric physics, cosmic rays, and upper atmosphere rocket studies.

The international coordination of this research program is being handled by the Special Committee for the IGY, set up by the International Council of Scientific Unions. The U.S. portion of the program is being prepared by the U.S. National Committee for the IGY, established by the National Academy of Sciences—National Research Council in response to an ICSU request.

Joseph Kaplan, AFIAS, Professor of Physics, University of California at Los Angeles, has been named Chairman of the U.S. National Committee. Included among the members of this committee are two other IAS members: Lyman J. Briggs, FIAS, Director Emeritus, National Bureau of Standards, and F. W. Reichelderfer, IAS Honorary Member and Fellow, Chief, U.S. Weather Bureau.

1953 Safety Contest Winners

The winners of the Aeronautical Industries Section of the 1953 Safety Contest, sponsored by the National Safety Council, were announced recently. The contestants—there were 30 of them—were divided into Group A and Group B.

The first-, second-, and third-place winners of Group A are: Douglas Aircraft Company, Inc., Santa Monica, Calif., with a frequency rate of 0.74; North American Aviation, Inc., Downey, Calif., with a frequency rate of 1.206; and Lockheed Aircraft Corporation's Georgia Division, Marietta, Ga., with a frequency rate of 1.208.

In Group B, the following companies came out in the first three places: Oliver Corporation, Battle Creek, Mich., with a frequency rate of 0.84; The Garrett Corporation's AiResearch Manufacturing Company Division, Los Angeles, Calif., with a 1.34 frequency rate; and Solar Aircraft Company, Des Moines, Iowa, with a frequency rate of 2.12.

During 1953, the 30 competing companies put in a total of 647,293,000 manhours of work, which represents a 4 per cent increase over the previous year.

Necrology

H. V. Wright

Harold Victor (Bob) Wright, MIAS, Managing Director of Bristol Aeroplane Engines (Eastern) Limited, died suddenly last March at his home in Rawdon, Quebec, Canada.

Mr. Wright spent his early life in Bristol, England, where he was born on November 19, 1899. He attended Dr. Bell's Church of England School in Bristol from 1907 to 1914. In the latter year, he became an Engineering Apprentice with the Bristol locomotive engineering firm of Peckitt & Sons. He left there in 1923 to join Bristol Aeroplane Company as an Engine Mechanic and Service Representative.

In May of 1929, he emigrated to Montreal, Quebec, Canada, and became affiliated with Canadian Wright Ltd. Over the next 21-year period, he served successively as Plant Superintendent, Works and Service Manager, and President. When Canadian Wright was taken over by The Bristol Aeroplane Company of Canada in July of 1950 and was renamed Bristol Aeroplane Engines (Eastern), Mr. Wright went along, becoming its Managing Director.

Mr. Wright is survived by his widow, Ada, a son, Peter, and a daughter, Marie.

News of Members

▸ **Brigadier General Milton W. Arnold** (AF), Vice-President—Operations and Engineering, Air Transport Association of America, has been appointed Chairman of the VORTAC Evaluation Committee of the Air Navigation Development Board. The VORTAC Committee was formed to evaluate the two systems of short distance air navigation: the VOR/DME and the TACAN systems. The committee has been directed to complete its work and present its final report by July 31, 1954.

▸ **Henry Konet** (M) has formed Konet Company, a consulting engineering firm specializing in gyroscopes, instrumentation, and controls. The company is located at 101 N. Franklin Turnpike, Hohokus, N.J. Mr. Konet was formerly Chief Engineer of Mechanical Instruments, Eclipse-Pioneer Division, Bendix Aviation Corporation.

▸ **O. T. Kreusser** (AF), Assistant to the General Manager, Allison Division, General Motors Corporation, retired on April 30. Mr. Kreusser designed and supervised the building of Allison's new product and engineering exhibit, the POWERAMA.

▸ **Dr. Hans W. Liepmann** (F), Professor of Aeronautics, California Institute of Technology, accepted an invitation from the University of Washington to become the first Walker-Ames Lecturer to the University's Department of Aeronautical Engineering. In this capacity, Dr. Liepmann delivered a series of lectures at the University of Washington from May 10 to June 4. The topics on which he spoke were: "Experimental Investigation of Problems in Engineering" and "Modern Problems of Fluid Mechanics."

▸ **Dr. Burt L. Newkirk** (AF), Professor Emeritus, Aeronautical Engineering, Rensselaer Polytechnic Institute, has been authorized by ARDC's Wright Air Development Center to continue his experimental study of oil-film whirl. This is the second extension of the contract that has been made since Dr. Newkirk began work on this project in April of 1951. The new phase of the research project continues to October 12 of this year.

▸ **Mundy I. Peale** (AM), President, Republic Aviation Corporation, has been named to the Hoover Commission's Task Force on Procurement. This group is studying ways of improving defense procurement, including inspection of contract performances, changes in contracts, financing of contracts, and pricing.

▸ **John L. Senior, Jr.** (M) has resigned from his position as Chairman of the Board, New York Airways, Inc.

▸ **Dr. Hector R. Skifter** (M), President, Airborne Instruments Laboratory, Inc., has been appointed part-time Consultant to the recently reorganized Air Navigation Development Board. Colonel J. Francis Taylor, USAF, is the ANDB Director.

▸ **Milton Denman Van Dyke** (TM), Aeronautical Research Scientist, Ames Aeronautical Laboratory, NACA, has been awarded a 1-year postdoctoral fellowship by the National Science Foundation. Dr. Van Dyke's fellowship is for advanced study and research in engineering during the 1954–1955 academic year and is to be accomplished at any accredited nonprofit education institution of higher learning of his choice either in the United States or abroad. The fellowship carries with it a stipend of $3,400 with additional allowances for dependents, tuition, and other normal expenses. In all, 79 fellowships for work in the natural sciences were granted.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are, therefore, urged to notify the News Editor of changes as soon as they occur.

Dr. Stanley U. Benscoter (AF), Aerophysics Specialist "A," Aerophysics Development Corporation. Formerly, Research Associate, California Institute of Technology.

Captain Robert V. Brulle, USAF (TM), Instructor, Aerodynamics Department, USAF Institute of Technology, Wright-Patterson AFB, Ohio. Formerly, Weapon System Officer, Fighter Section, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Gilbert Buitron (M), Design Engineer, Magnesium Company of America. Formerly, Product Test Engineer, Ford Aircraft Engine Division, Ford Motor Company.

Harm Buning (TM), Assistant Professor of Aeronautical Engineering, Oregon State College. Formerly, Research Associate, Engineering Research Institute, University of Michigan.

Rene Bussiere (M), Project Engineer, Controls and Accessories—Turboprop Engines, Wright Aeronautical Division, Curtiss-Wright Corporation. Formerly, Project Engineer, Advanced Engine Design, Wright Aeronautical Division, Curtiss-Wright.

F. A. Cleveland (M), Bomber Department Manager, California Division, Lockheed Aircraft Corporation. Formerly, Bomber Group Engineer, Preliminary Design Division, Lockheed.

Walter H. Dickman, AMIAS, Cofounder and formerly Chief Sales Engineer, Mineola Aircraft Engineering Company, recently formed Waldick Engineering Company to represent on the East Coast manufacturers of aviation and industrial products. The organization, located in Garden City, L.I., N.Y., is specializing in sales representation of aircraft components, accessories, and maintenance materials.

George J. Clingman (M), Supervisor, POWERAMA (a new product and engineering exhibit), Allison Division, General Motors Corporation. Formerly, Assistant Supervisor, Aircraft Power Plant Technical Training School, Allison Division, G.M.C.

Philip A. Colman (F), Chief Preliminary Design Engineer, California Division, Lockheed Aircraft Corporation. Formerly, Chief Aerodynamics Engineer, Lockheed.

H. G. Conway (AF), Chief Engineer, Short Brothers & Harland Limited, Northern Ireland. Formerly, Technical Director, British Messier, Ltd., England.

(*Continued on page 70*)

Carl L. Sadler, MIAS, formerly Chief Engineer, Hydraulic Division, Sundstrand Machine Tool Company, has been named Manager of the company's new Sundstrand Aviation Division. This new entity is devoted exclusively to the design, application, manufacturing, and servicing of constant-speed drives and accessories for the aircraft industry.

Editorial

NORTHERN NEIGHBOR

In the early days of Canada's growing aeronautical industry, it was only natural that her aeronautical engineers and scientific people should look to existing professional societies for the technical services they required. There were two principal aeronautical agencies available to them—Britain's Royal Aeronautical Society, to which many Canadians felt drawn for easily understandable reasons, and our own Institute of the Aeronautical Sciences, which had, beside other advantages, a strong appeal because of proximity. Then, too, the Engineering Society of Canada, whose membership was drawn "across the board" from all engineering activities in Canada, established aeronautical branches in an effort to attract professional aeronautical engineering people under its tent. All three organizations were able to do useful things for their constituents, but, as time went on, it became clear that the total Canadian aviation potential was not great enough to support any major activity by all three societies.

Over the past 5 years, a number of conferences have been held among all interested groups in an effort to work out the best plan for collaboration for the greatest good of all. Until recently, no completely satisfactory program was achieved. In various Canadian cities, the local groups worked out joint programs, and, in one case (Ottawa), an integrated Section organization was tried. We (the IAS) lent all the support we could

to these projects, and the Royal Aeronautical Society did likewise.

About a year ago, sparked by interested groups in Toronto, Ottawa, and Montreal, the idea of an all-Canadian aeronautical society began to take shape. Correspondence and meetings with representatives of both the RAeS and the IAS made it clear that both the older aeronautical societies had no thoughts other than to cooperate as fully as possible in setting up whatever plan, collaboration, or support necessary. It was notable that at no time was there any complication in the procedure engendered by any spirit of "competition" or by jockeying for advantage one way or the other. The objective was simply the establishment of whatever kind of organization was best to advance most effectively the aeronautical arts and sciences in Canada.

Finally, conversations took place in London in September, 1953, during the Fourth International Conference which gave the needed impetus. On February 6, 1954, the Canadian Aeronautical Institute came into official being, complete with constitution, bylaws, and a national headquarters and has already embarked on its first year's operation. Its first meeting was held in Ottawa on May 25, 1954.

The support that, by common consent, the Royal Aeronautical Society and the Institute are rendering to the new organization is more than moral. Both societies have agreed to the merger of existing RAeS and IAS Sections into CAI Sections and have undertaken not to promote any new and separate activity in Canada. Further, during the period when the new organization is struggling for financial self-sufficiency, both "parent" societies have agreed to turn over to the treasury of the CAI one-half the dues paid by Canadian members who retain membership in one of the older organizations and who also join the new one. In consideration of this form of support, the CAI will undertake to provide all the normal Section activities that we have heretofore rendered our separate Canadian Sections.

At its meeting of April 26, the Council of the Institute passed the following resolution:

> Resolved that the Secretary of the Institute of the Aeronautical Sciences forward to the Officers of the Canadian Aeronautical Institute our congratulations on the successful launching of that organization and our best wishes for its immediate and continuing success. Because of the close ties that bind us to our neighbors to the north, we pledge that we will do all possible to assist in this new venture that will help to advance the aeronautical sciences in Canada and throughout the Free World.

All members of the Institute join in extending to our new neighbor Society best wishes for a long and useful life!

S. P. J.

Optimization of Power-Plant and Airplane Performance

*A Symposium**

PANEL MEMBERS

Chairman

Philip B. Taylor
Sanderson & Porter

Aircraft

Robert L. Hall
Chief Engineer, Grumman Aircraft Engineering Corporation

E. H. Heinemann
Chief Engineer, El Segundo Division, Douglas Aircraft Company, Inc.

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Propulsion Requirements for Navy Jet Fighters

By

Robert L. Hall

There are a great many aspects to the problem of obtaining optimum aircraft performance. The special problem I plan to discuss here is the optimization of power plants for carrier-based Navy jet fighters.

In designing a carrier-based airplane, both the airframe contractor and the engine contractor are subject to two basic limits that they have no power to change and which, in themselves, have small potential for change.

The first of these limits is a dimensional factor and is dictated by the accommodations aboard the carrier and the number of aircraft required in squadron quantity to support the carrier task.

The second limit is a time factor and is dictated by the period needed to reorganize the deck between launching and recovery of the aircraft.

The dimensional factor governs not only the size and weight of the airplane but, to some extent, its tactical concept. The carrier is too limited in space to accommodate more than a limited number of single-purpose airplanes. Therefore, the Navy fighter must be able to perform missions of various types. These missions may include sea-level strafing through mountain terrain, photographic reconnaissance, and ground-force support, as well as the better known problems of interception.

Whatever its capacity for missions, however, the Navy fighter is unsuitable for its work unless it is designed with the time factor in view. This factor sets

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the minimum interval in which the airplane must stay air borne before its recovery by the carrier.

As you know, there have been many recent improvements in carrier deck-handling equipment, and these have resulted in some decrease in the time the airplane must stay air borne. However, this decrease is negligible in comparison with the range and endurance penalties associated with trends toward high speeds. Moreover, the improvements in speed have in themselves served to introduce a further complication, since they tend to bring the aircraft back to the carrier earlier in the time schedule than before. As a result, the aircraft must often wait for an opportunity to land. This means that power-plant efficiency losses of an order that once might have been negligible may now be serious from the standpoint of mission cycle time.

The overall problem may be clearer if I express it in terms of required fuel. To put it approximately, only about 28 per cent of the fuel on a Navy fighter is usable for range. Of the remainder, 8 per cent will normally be used for take-off, 12 per cent for rendezvous and climb to altitude, 30 per cent for tactical mission, and 15–20 per cent for stack-up prior to landing. Thus, maximum efficiency is required not only for $V_{max.}$ but for the opposite extreme of the flight regime.

If I have taken this opportunity to review the mission problem of the Navy fighter in such detail, it is because I feel it has an extremely significant bearing on the suggestions we have to make on optimizing the air-frame engine combinations.

The first suggestion is directed to Government procuring agencies:

In the past, it has been the practice of procuring agencies to conceive of the aircraft engine as an entity in itself and to call for a unit that ideally combined minimum weight with maximum power, reliability, and adaptability to various aircraft. This concept must be revised if power-plant optimization is to be realized on future aircraft. With the advent of supersonic speeds, the engine and aircraft are so closely integrated that they must be considered as a combination.

To achieve the best combination, the engine manufacturer, whose product takes approximately 4 times longer to develop than the air frame, should be given a commensurate lead time. Otherwise, the strategic concept of the airplane is likely to become obsolete before the engine is available.

In addition, the procuring agency's engine specification should provide a better definition of the mission problem for which the engine is intended, instead of merely specifying values of thrust and specific fuel consumption. It is believed that such a definition would enable the engine designer to provide features much more compatible with the ultimate use of his product.

The remainder of the suggestions are directed to the engine manufacturer:

(1) *For single-engine applications, emphasize the development of configurations that are small in diameter and long rather than large in diameter and short.*—Within reasonable limits, the air-frame engineer can—and, in fact, usually must—design around the engine envelope that is given him. At the present time, however, it is simpler to design a single-engine fighter with good stability and density characteristics if long slender engines are used.

The reason is that present engines normally constitute 20–25 per cent of the airplane weight empty. Therefore, the basic engine must be located on the airplane c.g., which is also required for disposable loads such as fuel and armament. Recently, available space in this area has been even further constricted by such high-speed aerodynamic features as thin wings and indented fuselages. It is obvious, therefore, that reductions in engine diameter will assist in solving the space problem in this area.

In working toward the reduction of engine diameters, it should be remembered that insofar as the air-frame manufacturer is concerned, minimum diameter is minimum diameter *with the accessories installed*, since this is the dimension he must consider with respect both to volume distribution and removal problems. In formulating the basic design concept of the engine, therefore, it should be considered whether a better deployment of volume may not be obtained in the ultimate installation, through remote location of the accessories. This would minimize the removal envelope of the engine, reduce the need for access doors in the highly stressed c.g. area of the airplane, and provide for a denser and more equitable distribution of volume throughout the airplane.

If it is not feasible to obtain reductions of cross section by standard methods, it is suggested to further explore the possibility of using some of the more high-density fuels of the hydrocarbon category.

All these factors will have a direct influence on the size and endurance of the airplane.

(2) *Place more engineering emphasis on the engine afterbody design, with special reference to exit-nozzle configurations.*—I feel I should stress at this point that it is no longer enough for the engine designer to know internal aerodynamics. He must know external aerodynamics as well. He must understand the close relationship of optimum tail length, airplane afterbody contouring, and fuselage slenderness ratio. He must realize the importance of integrating external flow with flow from the jet and ejector so that maximum net thrust is obtained.

To illustrate this point: It has been our experience that the gains achieved through design concentration in this area can offset the total drag of the wing or equal the drag decrease realized from great refinement of the wing-fuselage area. By the same token, failure to concentrate on this area can result in equivalent losses. In terms of net thrust, such losses for a high-speed single-engined fighter could range from 4–11 per cent.

For this reason, it is mandatory that the engine designer include in his initial concept (a) a method of permitting adjustments in the overall length of the engine and (b) selections in exit-nozzle design and external

shrouding which can be blended with fuselage afterbody treatment. While this will impose a severe burden on the engine manufacturer, we consider the burden justified by the magnitude of the thrust factors involved.

The engine manufacturer must further realize that the engine afterburner and exit-nozzle area is far more critical than the compressor area for balance effects on the airplane. Therefore, any weight-saving he can achieve in this area will be advantageously reflected in terms of airplane stability and overall length.

He must also consider that the type of engine afterbody suspension he selects can have a definite effect on performance. This is particularly true for carrier-based aircraft.

Let me explain in detail: During the arrested landing of a single-engined jet fighter, the afterbody may sustain vertical loads of 18–20 *g*'s and axial loads of 4–5$^1/_2$ *g*'s. If the engine is mounted in standard cantilever fashion, the aircraft designer must provide a clearance of 1$^1/_2$–2 in. between the engine afterbody and the airplane tail, to allow for relative deflections. The resultant clearance envelope creates an inherent ejector configuration that not only is large in base area but requires large quantities of air to be pumped. Such a configuration penalizes performance in two ways:

(a) It increases base drag on the fuselage. (This increase can range from 1–3 per cent, or even more.)

(b) By increasing requirements for pumping, it reduces available thrust. (This decrease can range from 10–15 per cent during cruise.)

These are appreciable factors in terms of both speed and fuel consumption for range. They could be greatly reduced, without introducing new problems of any great significance, by substituting flexible suspension for cantilever afterbody mounting.

(3) *Refine the engine controls with a view to utilizing full engine potential at the most critical phases of flight operation.*—I think it can be said of engine-air-frame combinations of all types that one of the chief obstacles to optimization is not apparent in the design phase of development. The engine manufacturer can preconceive with reasonable accuracy the structure and temperature limits of his engine; hence, the basic design concepts of the engine and air frame are relatively easy to integrate in terms of geometry and performance.

So far, however, the engine manufacturer has been unable to achieve the same accuracy in preconceiving engine controls. Thus, the real obstacle to utilizing full engine potential arises from the operational limits that ultimately develop because the engine controls compromise predicted available power.

So long as the trend is toward increased use of automatic controls, more effort must be made to match the controls in quality, in reliability, and in schedule, to the actual thrust potential of the engine. A practical solution will not be easy to find. However, concentrated efforts toward control refinement can yield worth-while dividends in engine compatibility for all phases of the aircraft mission.

In short, what is desired from the engine designer is closer concentration on long slender configurations, exit-nozzle and ejector configurations, and engine controls. With all this, of course, the engine should still be designed for production, as well as performance.

I know that by now representatives of engine manufacturers must be waiting with some impatience to ask: "Why put the whole performance burden on us? Why not improve the air-frame design?" My answer is—and I am sure I can speak for other companies as well as my own—we *are* improving the air-frame design. But the air-frame design can no longer be developed independently of the power plant. Moreover, we have found that even the crudest improvements in installed net thrust can result in performance gains equivalent to those obtained through long and expensive programs for aerodynamic refinement. For this reason, we feel that the power plant, while not the only place, is the most profitable place where present efforts toward optimum performance can be directed.

Practical Considerations in the Optimization of Airplane and Engine Performance

By

E. H. Heinemann

The optimization of airplane and engine performance is a rather broad and involved subject, including both technical and practical considerations.

The usual design studies for an engine or airplane consider most technical aspects in great detail, but they often fail to be tempered by practical considerations, such as timing or availability, reliability, and other important considerations. The consideration of practical aspects during initial design stages is most important and may actually short-cut a large amount of detailed and meaningless analysis, as well as developmental work. Essentially, the injection of practical aspects—if properly considered—should not discourage design studies but rather should shorten them and make them more accurate. It is intended that this discussion point out some of the practical considerations that are so important to the airplane-engine combination.

Among the most important of the practical considerations are the following:

(a) Size of power plant with consideration of its growth potential.

(b) Interchangeability of engines.

(c) Realistic evaluation of the engine company's performance estimates.

(d) Careful analysis of the need for afterburners.

(e) Single vs. multiengine considerations.

(f) Internal or external engine mountings.

Detailed discussions regarding the foregoing items are offered as follows:

(a) *Size of Power Plant.*—To obtain an optimum engine for each airplane requirement would result in the

development of an infinite number of engine sizes. This would obviously be impossible. The selection of an engine or engines therefore usually narrows down to the most powerful engine available to meet the performance requirements without penalizing the basic purpose or mission of the airplane.

A review of a large number of airplane designs of the current generation of new models, both military and commercial, appears to indicate that the nominal 40-in. engine size is extremely good. With proper development, it appears that this size engine will be usable for even a second generation of new airplanes and perhaps longer, since one such engine is suitable for a fighter, two for medium bombers, and four for commercial transports and larger military aircraft. Smaller or larger engines can be shown to have certain advantages on paper, but development times required for new engines would appear to give the present 40-in. size a distinct advantage.

(b) *Interchangeability of Engines.*—Interchangeability of engines of substantially the same size or power is of course a big headache to the engine manufacturer. It is a distinct advantage, however, to the airplane manufacturer, as well as to the operators. While complete interchangeability would be difficult to achieve, it is believed that more coordination in the establishment of space envelopes and possibly even mounting fittings for engines is extremely desirable and to the best interests of all concerned.

(c) *Realistic Evaluation of the Engine Company's Performance Estimates.*—A realistic evaluation of an engine company's performance and delivery estimates is most important. Recent experience has shown that the development of a high-performance reliable engine is a greater job than was realized a few years ago. Furthermore, keen competition resulting in a rather high degree of overzealousness on the part of the engine manufacturer, together with the pressure from the aircraft designers, has resulted in the selection of engines that could not be delivered or were not ready for service use. While there will probably be less of this overselling in the future, it must be carefully guarded against, since it is a common product of competition and eagerness to get business.

(d) *Afterburners.*—Afterburners in spite of their high fuel consumption, are, at present, apparently necessary for certain high-performance airplanes, such as interceptors and supersonic fighters. Unfortunately, as the result of the emphasis on high speed, afterburners have frequently been placed into use only to show a high level-flight speed, which in some cases has required more minutes of afterburner operation to obtain than the afterburner time allowed by the combat radius problem. Thus, the airplane requires all its afterburner time allowance to reach a maximum velocity and has no time left for combat at maximum velocity.

Except for the interceptors and extreme high-performance airplanes, it would appear that better airplane engine combinations could be obtained by the selection of a more powerful engine without afterburner. Present indications are that afterburners pay their way only in relatively short range, high subsonic and supersonic fighters and are not practicable for transports and bombers, except perhaps in some specialized bomber applications.

(e) *Single vs. Multiengine.*—The single vs. multiengine consideration is at the present time highly controversial. There is no question that a four-engined airplane has a distinct advantage in the transport field owing to the Civil Air Authority "one engine out" requirement. This requirement also rules out a single-engined transport.

In the field of military aircraft, however, the selection of number of engines appears to be more a matter of thrust required. If one engine will do a job, recent experience has shown that it will result in the lightest and most efficient installation. In general, combat experience during World War II and in Korea has shown that single-engined airplanes actually have a high degree of reliability and that they have a higher degree of availability than twin-engined airplanes.

Since the advent of jet engines, there appears, especially on paper, an advantage in having two smaller jet engines instead of one large one; first, because it appears that the basic engine weight for a given thrust is a minimum for engines of relatively small size, and, second, because the greater low-altitude endurance or radius can be achieved by cruising on one engine. The latter has actually been demonstrated on some airplanes having two smaller engines. Nevertheless, when it is considered that most jet operations are at high altitudes where endurance and operating radii can be obtained without shutting off an engine, plus the considerations that twin-engine installation weights usually are greater than for single-engine installations because of extra fire wall material, duplication of engine and airplane accessories, etc., and the fact that the development of smaller engines has lagged behind the development of larger engines, it appears quite doubtful that twin-engine installations will gain more popularity over a single-engine selection of equivalent power in the foreseeable future.

(f) *Internal vs. External Mounting.*—Internal vs. external mounting of power plants is at present highly debatable. There are strong arguments in favor of both. It has been clearly demonstrated in the fighter-type aircraft that internal mounting of engines is satisfactory and results in lowest drag inasmuch as the engine body can be mounted in the "aerodynamic shadow" of the pilot and radar equipment. This obviously results in the lowest frontal area.

In bombers where a bomb bay is required and in transports where the fuselage is primarily utilized for passengers, it becomes extremely difficult to install engines within the fuselage. Wing root installations have been successfully developed in England, and external pod-type installations have been successfully used in this country. The weight and supersonic drag advantages are in favor of the buried engine, but, as speeds increase and wings are reduced in thickness, it be-

comes more difficult to house engines within the wing contours except possibly where large wing chords are used. Externally mounted engines also appear to have a distinct advantage insofar as the fire hazard is concerned.

It is evident that the power-plant installation for each particular airplane must be carefully considered, taking into account the many influencing factors.

In conclusion, it would appear:

That the present 40-in. engine size is an extremely good size and compatible with most aircraft under consideration, from fighters to heavy bombers and transports.

That greater coordination between procurement agencies and engine manufacturers to arrive at a standard space envelope would be extremely desirable.

That afterburners should only be used where absolutely necessary owing to their high fuel consumption.

That single-engine arrangements for interceptors, fighters, and light attack airplanes are more desirable than twin-engine arrangements unless the thrust requirement is greater than obtainable in one engine.

That satisfactory installations of either pods or buried engines can be had but that there are practical and safety advantages in the use of pods, especially on multiengine airplanes such as transports and bombers, even though at a slight loss in performance.

Suggested Supersonic Design Considerations

By

R. J. Woods

The design and construction of aircraft capable of sustained supersonic flight is a current major effort in the aircraft industry both here and abroad.

Military types constitute almost entirely the current research and development effort on supersonic aircraft, and it appears they will continue to do so for the next 10 years or so. Sustained supersonic capability is desired in most military types of aircraft and, in some cases, is urgently needed.

The high cost and time period required for design and development of operational supersonic aircraft limit the number of projects which can be supported and place a high premium on making the right selection and proper compromise of characteristics compatible with its intended use on any supersonic aircraft project initiated.

The basic problem of selection and evaluation of aircraft and component characteristics to produce an optimum aircraft design for an established operational requirement is well known and is usually well executed in the aircraft industry today on aircraft projects where the sustained speed requirements are *subsonic*. There is a natural and prevalent tendency to carry subsonic aircraft and component design concepts and procedures into supersonic projects, and there exists considerable scientific and technical evidence that indicates that this is an incorrect approach to the problem. This is certainly true where long-range supersonic flight is desired. In other words, to realize the optimum capability within the limits of the available technical and scientific know-how in supersonic aircraft, it is believed necessary to consider that *the rules change*, subsonic design techniques and procedures need careful scrutiny, and basic concepts need change.

The reason it can be said the rules change for basic evaluation of the design concept is that, in the change from subsonic flight speeds to supersonic flight speeds, a large variation in the relationship of the air frame and the power-plant system, including the fuel load, takes place, and the relative importance of the air frame and power plant appears to reverse positions. This circumstance appears to have been generally accepted in supersonic rocket and missile design and development where almost invariably the power plant and fuel supply is the primary design and concept effort. A suitable air frame is then developed—not without difficulty, sometimes—to house and carry the power-plant system.

The Armed Services and the aircraft and power-plant industry have been slow to accept a conclusion that procedures and techniques proved for subsonic design should be thrown overboard and a new contrary appearing set of techniques and procedures be established for supersonic designs. In fact, there is actual resistance against such change, particularly in the power-plant industry and in the technical staffs of the Services. The standard response to the suggestion that new approaches to the problems of the basic design compromise for supersonic flight speeds be established is, "Oh! That has all been done," or "we are doing it." The fact remains that, except in missile and rocket work, it has not been done because it requires an obvious cart-before-the-horse type of procedure change, which is not in evidence.

This is, then, an appeal to the military and to the aircraft and power-plant industries to inspect carefully and evaluate the basic operational requirements on all new supersonic aircraft projects, on a basis of the suitability of the intended power-plant system, prior to consideration of the air-frame design problem. Some of the reasons for this are briefly:

(a) As speeds change from subsonic to supersonic, the drag coefficients for the air frame and its components take a minimum rise of 200 to 300 per cent because of the character of compressible airflow. This drag coefficient increase, coupled with the velocity square function of aerodynamics, produces very large total drag increments and, hence, requires very large power-plant net thrust increases.

(b) Large power-plant net thrust increments mean more thrust without more weight or drag, and this brings into consideration jet-engine augmentation, ramjet, and rocket power plants. These high-output power plants develop their large net thrust increments at the expense of increased specific fuel consumption; turbojet afterburners running about 200 to 250 per cent higher; ramjets 300 to 400 per cent higher than straight turbo-

jets; and rocket engines 400 to 800 per cent higher than straight turbojets.

(c) With total drag increments of approximately 800 per cent and specific fuel consumption rate increments of 200 to 800 per cent for a change in speed from Mach = 0.9 to Mach = 1.8, the pounds of fuel used per mile flown get into the 800 to 6,000 per cent increment range over conventional subsonic straight turbojet operation. Thus, it becomes obvious where the shoe pinches when sustained supersonic speeds are required. The high fuel consumption per mile flown also tells why there is no urgent consideration for supersonic commercial air transport development.

(d) From the foregoing, it can be seen that, in changing from subsonic flight speeds to supersonic flight speeds, power-plant functional characteristics and compromises which were insignificant details of refinement compared to air-frame functional characteristics at subsonic speeds change in their relative importance to the whole at supersonic speeds. In other words, for sustained supersonic flight speeds, the engine, its functional environment, and its fuel supply become the major item of weight and tend to determine and limit air-frame configuration. Since any supersonic air frame must be one with thin airfoils and fine, slender bodies, the engine, its environmental installation, and the size of the fuel supply control the aircraft total drag to a degree as well. It is then the story, as in rockets and missiles, that for supersonic flight speeds the power-plant system becomes the major aircraft design controlling component with the air-frame configuration rated as secondary. This reversal of positions between the air-frame and power plant as the major controlling component of the complete aircraft is the rule change that requires revisions of subsonic aircraft design concepts, techniques, and procedures if maximum capability within the limits of our scientific and technical know-how is to be utilized. Our failure to maximize the capabilities of our new supersonic aircraft will not, of course, prevent others from doing so.

(e) The actual procedure to be followed to maximize supersonic flight capabilities in an aircraft type can be briefly outlined as follows:

(1) Profiles of the flight missions for which an aircraft is intended should be developed. The various parts of each flight mission should be tabulated in time or distance and weighted by assumed factors in their importance to the overall flight mission.

(2) An assumed air frame that has reasonable parameters of size, weight, installations, and crew should be set up for trial power-plant system evaluation, with the additional assumption that the air frame will not be restrictive on the power-plant system requiring compromise from an optimum power-plant system installation. This means engine air intakes, diffusers, ducts, engine arrangements, and exhaust systems can be set up to be as efficient as the state of the art permits.

(3) The flight mission plan should then be studied, applying the available type of power plants such as turbojet, turboprops, ducted fans, ram-jets, and rockets and combinations of these basic types in an effort to arrive at an optimum power-plant system for the use intended.

(4) The studies of the individual missions should then be compared, the compromises needed to perform all the required flight missions assessed to see if the type concept is practical, and a conclusion reached on the size, type, and general arrangement of the optimum power-plant system for the intended use.

(5) A power-plant design and development project should then be initiated and carried to the point where it can be assessed as feasible and suitable and where the engine size, configuration, and installation are reasonably well established. It is thought this might take 1 to 2 years, which happens to just fit the difference in time between new air-frame and engine development programs.

(6) When the power-plant system is qualified as capable of doing what it is intended to do and in existence in experimental form so it can be described, seen, weighed, and measured, an air-frame design competition should be initiated with the premise that the winning air-frame design will be the one that best provides for the specialized installations and crew required for the type and which penalizes the optimized power-plant system the minimum. Such an aircraft design provides maximum capabilities within the limits of our know-how.

(f) Certain problems are recognized:

(1) The aircraft engine industry has not been in the conceptive design field much, as in the subsonic past the engine was a secondary component to the air-frame and engine type. Engine design and engine installation compromises were generally acceptable in the interest of wide utility, so engines came in sizes much as propellers for reciprocating engines did 20 years ago. The engine industry's job was to build a good standard universal engine that would have wide acceptance by various air-frame contractors and by Armed Service and Transport agencies. Advanced concept and specialized engines, occasionally offered, failed to be set up because it was a subsonic era.

(2) The air-frame industry is loaded with conceptive design specialists and can and does produce more new air-frame design proposals than can possibly be assimilated. The air-frame industry has a big job still to come for its designers and engineers to accomplish the refinements needed for satisfactory flight control and stability at supersonic speeds, but this phase will come *after* the power plants are produced to provide sustained operational supersonic speeds.

(3) One solution to this problem of having the concept design specialists in the wrong place would be to transfer these people from the air-frame companies to the engine companies for a year or so. A second advantage of such an exchange would be the good effect a little cross-breeding would produce, to gain a better understanding of the other fellow's problem, which becomes more

necessary as the power plants and air frames become more homogeneous and specialized.

(4) The lovely dream of mass producing one universal aircraft engine—and we are at it again now—which can be tooled-up in an automatic factory, seems doomed unless it is accepted at a decrease in aircraft capability in supersonic flight or unless all aircraft requirements can be condensed into one flight plan. Specialized and custom-tailored power plants seem to be required for supersonic flight.

(5) Sales talk, inertia, and resistance by the engine industry against becoming flexible and generating advanced concepts and optimized power-plant systems cannot be accepted unless the all-powerful engine industry will agree to tell our potential enemies they cannot do thus and so either.

(6) To support the air-frame assumption, a quick analysis of a good supersonic aircraft design will show that engine and engine installation compromises, which at subsonic speeds have been small, can reduce the range at supersonic speeds by 15 to 20 per cent, while air-frame configuration changes such as delta, straight wing, or even biplane can be made, as long as the wings and fuselage stay thin and clean, for a maximum reduction in range at supersonic speeds of 2 to 4 per cent. This means we must evaluate the power-plant factors that control large variations in overall aircraft supersonic capabilities rather than air-frame factors that control smaller variations.

The conclusion is reached that any new aircraft project requiring sustained supersonic flight will be so costly and time consuming that anything less than the optimum capabilities permitted by our state-of-the-art know-how is not acceptable. Strict and careful programing and evaluation under new rules must be established and maintained in the Services and in the air-frame and aircraft engine industries to see that our new aircraft are optimized if we intend to be superior in the air. At a recent meeting in England with Dr. Cockburn, Scientific Adviser to the British Air Ministry, he stated that he believed that, should war with Russia come, the side with the best aircraft engines would eventually win. I believe this is a profound and true conclusion.

The Best Use of the Energy from a Turbine Engine for Aircraft Propulsion

By

L. G. Dawson*

To help decide the best way to fly an aircraft with a turbine engine, one should have a number that defines the usefulness of the engine aircraft combination. A convenient number is the weight of the aircraft, multiplied by the distance flown, divided by the total fuel energy supplied. This may be written in an exactly equivalent form that is more convenient: the weight of the aircraft, multiplied by the forward speed, divided by the rate at which fuel energy is supplied. This number is a work-done efficiency, since the work done in flying the aircraft from one point to another is the drag multiplied by the distance flown. It is more convenient to use the weight of the aircraft in place of the drag and to consider the lift-drag ratio as one of the quantities involved. If we call this number the aircraft efficiency, we find it is the product of the lift-drag ratio at which the aircraft is flown, the propulsive efficiency of the power plant, and the thermal efficiency of the power plant. It is also simply related to the miles flown per pound of fuel and the aircraft weight. If the proportion of the weight of the aircraft which is useful load is known, then this number defines the fuel required to carry the useful load from one point to another in level flight. The derivation of the aircraft efficiency is very simple and is shown in Appendix 1. Fig. 1 is a reproduction of this appendix. The effort of the aircraft and engine designers is combined to give the highest aircraft efficiency factor possible for long-range load-carrying machines. The engine man can only contribute to the propulsive and thermal efficiency, the lift-drag ratio being decided by the aircraft designer. For a modern transport aircraft using efficient piston engines, the aircraft efficiency factor is between 4.7 and 4.9. The question is how we should use the energy from a turbine engine to produce the maximum value of the product of the propulsive and thermal efficiencies.

AIRCRAFT EFFICIENCY FACTOR

$$\text{AIRCRAFT EFFICIENCY} = \frac{W.V.}{F} = \frac{L}{D} \times \frac{D.V.}{E} \times \frac{E}{F}$$

$$= \frac{L}{D} \cdot \eta_P \cdot \eta_{TH}$$

SINCE DV = WORK DONE
E = MECHANICAL ENERGY IN GAS SUPPLIED PER SECOND
F = FUEL ENERGY SUPPLIED PER SECOND
η_P = PROPULSIVE EFFICIENCY
η_{TH} = THERMAL EFFICIENCY

IF THE FUEL CALORIFIC VALUE IS 18,500 B. TH. U. PER POUND

THEN :-

$$\frac{W.V}{F} = \text{NAUTICAL MILES PER POUND FUEL} \times \frac{\text{AIRCRAFT WEIGHT POUNDS}}{2370}$$

FIG. 1.

The factors that affect thermal efficiency are well known. To improve thermal efficiency, we strive to increase the efficiency of turbines and compressors, raise the pressure ratio of the cycle, and increase combustion temperature. Let us not enter the discussion of thermal efficiency, except to mention that, if we had turbines and compressors of 100 per cent efficiency, then the thermal efficiency would not depend on the maximum temperature of the cycle but would only depend on the compression ratio. This raises a question to which we may return later.

* The author wishes to thank the Westinghouse Aviation Gas Turbine Division for its assistance in preparing material for this paper.

For the remainder of the discussion, let us assume we have a basic jet-engine cycle working with a certain thermal efficiency that produces a certain energy in the tailpipe. We will then consider how we may use this energy to fly the aircraft in the most efficient way. Fig. 2 shows the three ways we may use the energy produced by the basic cycle. We may eject it from the tailpipe; we may use some to drive an airscrew or some to drive a ducted fan. Imagine a fixed quantity of airflows through the combustion chamber of all three types of engine; they have the same pressure ratio and the same maximum temperature and, therefore, use the same amount of fuel. If we consider the jet engine as our reference engine and measure the thrust of the other two as a ratio to this, then the propulsive efficiencies will be in the ratio of the thrusts, and, since all three engines are using the same quantity of fuel, specific consumption will be in the inverse ratio. Having chosen the reference jet engine that produces a certain energy in the tailpipe, we use the same cycle in the turboprop and fan engine but, in each case, distribute the energy so that the turboprop and fan produce the maximum thrust of which they are capable under the flight conditions chosen. The conditions for optimum thrust are shown in Fig. 2. In the case of the propeller engine, the velocity of the exhaust gas should be in a fixed ratio to the flight speed, depending on the efficiency of the propeller and the turbine driving it. In the case of the fan engine, the velocity of the cool air leaving the fan is in a fixed ratio to the velocity of the hot gas leaving the tailpipe, the ratio being decided by the efficiency of the turbine and the fan that it is driving. If we consider that these engines are always designed for their optimum condition and calculate the

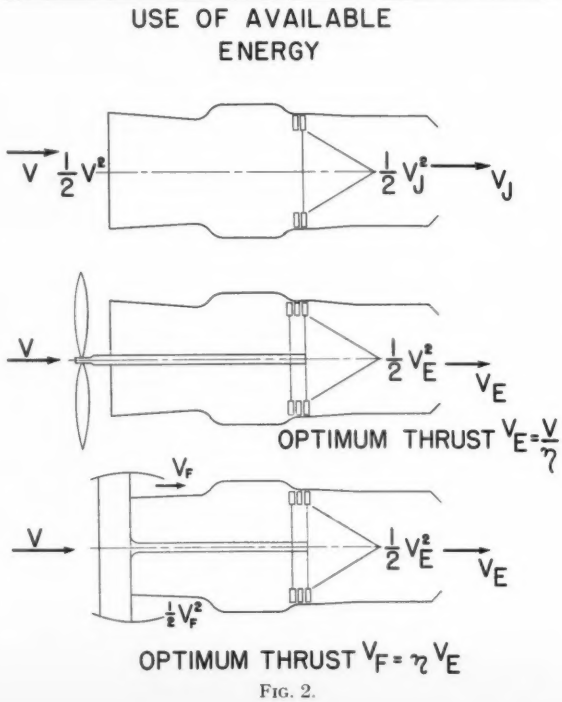

Fig. 2.

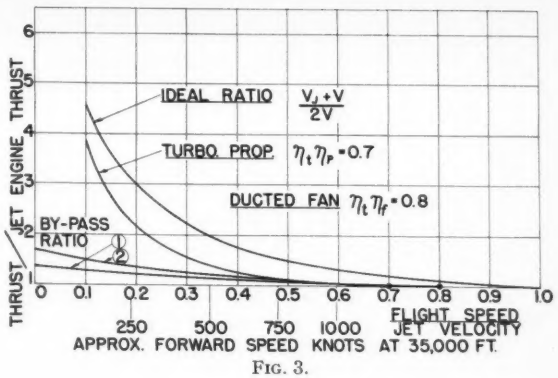

Fig. 3.

ratio of their thrust to the thrust of the jet engine from which they were derived, we find that this thrust ratio depends on a single number. That number is the ratio of the velocity with which the parent jet engine would have discharged its hot gas, to the forward speed of the aircraft. An outline of the calculation of the optimum conditions and the thrust ratios is given in Appendix 2. Fig. 3 shows the thrust of the turboprop and fan engines plotted against the ratio of flight speed to the jet velocity. The jet velocity used is the velocity with which the parent jet engine would have discharged its gas direct to atmosphere. Each point on the curves for the turboprop and fan engine represents a different engine designed, so that it is giving maximum thrust according to the optimum conditions already derived. In drawing this diagram, one had to assume constant efficiencies with forward speed. The propulsive efficiency of the turboprop will undoubtedly change with forward speed, but, in the case of the fan, the efficiency variation will be small, and for this engine the diagram nearly represents the real case. Fig. 3 shows an extremely interesting effect. The thrust of the turboprop engine equals the thrust of the jet engine when it is used at a flight speed of 0.7 of the jet velocity of the parent jet engine. The factor 0.7 comes from the efficiencies assumed for the turboprop and the turbine driving it. The ducted fan shows the same effect, and in this case its thrust equals the thrust of the parent jet engine when the flight speed is 0.8 of the jet velocity of the parent jet engine. This is a perfectly general result that may be proved as indicated in Appendix 2. An interesting point is that the conditions under which the fan engine has the same thrust as the parent jet engine do not depend on the by-pass ratio of the fan, and it will be clear that, with the simple assumptions shown, the speed at which the fan engine thrust equals the jet-engine thrust using the same cycle is extremely high. At speeds lower than this, the fan engine will always give a greater thrust while still using the same quantity of fuel. At lower speeds, the increasing thrust depends on the by-pass ratio. The greater this ratio, the higher the thrust, but the more the weight and frontal area of the engine. Now it so happens that, if one calculates the jet velocity of a large number of jet-engine cycles and uses practical combustion temperatures, then the ratio

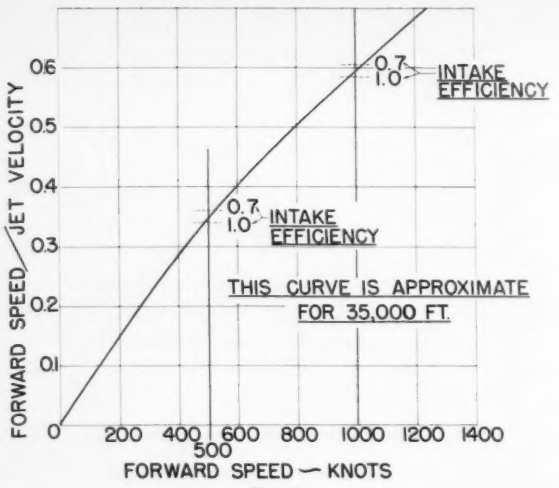

FIG. 4.

forward speed divided by jet velocity is almost independent of the type of cycle. Changes in component efficiencies and pressure ratio have little influence on this curve. This enables us to assign an approximate speed scale to the diagram, and it will be seen that, provided the fan engine is designed for optimum conditions, it gives a greater thrust than the parent jet engine at remarkably high speeds. Fig. 4 shows the approximate curve, relating the ratio of forward speed to jet-engine jet velocity and flight forward speed. This curve is not exact but is near enough for this discussion. In Fig. 5, we have enlarged the section of the diagram dealing with the fan engine. This shows clearly the remarkable fact that the speed at which the fan engine gives the same thrust as the parent jet engine from which it is derived does not depend on the by-pass ratio. At lower speeds, the more the by-pass ratio, the higher the thrust. You may wonder why this curve was plotted against flight speed divided by the jet velocity of the parent jet engine. Fig. 4 is only approximate, and, by plotting Fig. 5 in this way, we can derive more information from a very simple curve. We have already seen that the point at which the thrusts become equal is easily defined. As time goes by, we shall raise the maximum temperature of our basic cycles and possibly increase the pressure ratio. Whatever the configuration of the parent jet engine, this diagram still applies. We shall find that all our jet-engine development tends to increase the jet velocity. This means that the ratio flight speed to jet velocity for subsonic aircraft will tend to decrease with time and shows the fan engine to ever increasing advantage; but remember that the fan engine must be designed with the optimum ratio of discharge velocity from the fan and the tailpipe. Again considering Fig. 5, both the parent jet engine and the fan engines with different by-pass ratios are using the same amount of fuel. In the overall assessment, it is necessary to consider the engine weight and frontal area. But if we return to the aircraft efficiency factor with which we started, we can see that the fan engine makes a useful contribution to the propulsive efficiency at the speeds at which load-carrying aircraft will probably fly.

In this discussion I have deliberately expressed the results as a ratio to the parent jet engine. By so doing, we found that the performance of the optimum turboprop and fan engines could be specified by a single number and also made the results independent of pressure ratio or the combustion temperature of the cycle which was common to the jet engine and the derived engines. It might be as well to just consider the parent jet-engine cycle for a moment. At the beginning, I remarked that, were we able to have compressors and turbines of 100 per cent efficiency, then the thermal efficiency of the engine would only depend on the pressure ratio and not the maximum temperature of the cycle. Suppose we were clever enough to produce such an engine. Then, we could alter the maximum temperature of the cycle to suit ourselves. Now, at a fixed flight speed, the propulsive efficiency of the jet engine only depends on the jet velocity, and the lower the jet velocity, the higher the propulsive efficiency. With fully efficient compressors and turbines, we could in principle decrease the maximum temperature of the cycle and so decrease the jet velocity to achieve any propulsive efficiency we chose. The only limit to this process would be the size and weight of the engine, since propulsive efficiency is only increased by accepting a lower thrust per pound of air. Even on present engines, the optimum of the product of thermal and propulsive efficiency occurs at a combustion temperature lower than that which may be used with present-day materials, and the specific consumption of the jet engine may be improved to a certain extent by using this effect. Unfortunately, having done this, one is always in the position of asking for more thrust from a given size of engine. And the only way this may be obtained is by raising the combustion temperature, and this brings with it a deterioration in propulsive efficiency and a rise in the specific consumption. However, in the case of the ducted fan engine that may be derived from any jet-engine cycle, this effect does not arise, since one may increase the by-pass ratio slightly to keep pace with the increase in combustion temperature, thus holding the

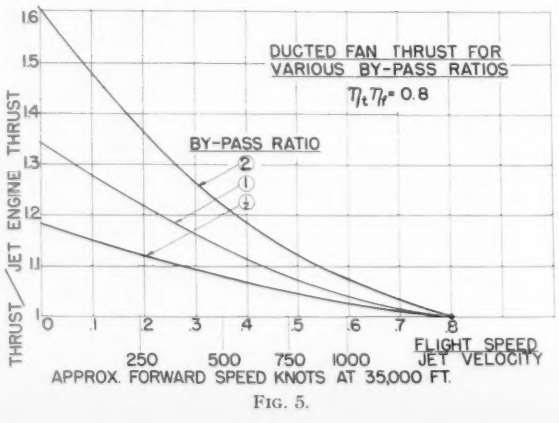

FIG. 5.

propulsive efficiency and improving the thermal efficiency.

Appendix 1

Notation

V = flight speed
V_j = velocity of discharge from jet engine of gas having energy $^1/_2V_{j2}$
V_e = velocity of discharge of hot gas from turboprop or ducted fan engine
V_f = velocity of discharge of air from ducted fan
η_p = propulsive efficiency of propeller in turboprop
η_t = turbine efficiency of turbine-driving propeller of fan
η_f = efficiency of fan in ducted fan engine
η = $\eta_p\eta_t$ or $\eta_f\eta_t$
η_{th} = thermal efficiency
W = all-up weight of aircraft
D = drag of aircraft
L = lift
E = mechanical energy in gas
F = fuel energy
M = fan airflow—i.e., flow passing round the combustion chamber/flow through the combustion chamber

Aircraft Efficiency Factor

$$\text{aircraft efficiency} = \frac{W\cdot V\cdot}{F} = \frac{L}{D} \times \frac{D\cdot V\cdot}{E} \times \frac{E}{F}$$

$$= \frac{L\cdot}{D} \times \eta_p \times \cdot\eta_{th}$$

since

DV = work done
E = mechanical energy in gas supplied per second
F = fuel energy supplied per second

If the fuel calorific value is 18,500 B.t.u. per pound, then $(WV)/F$ = nautical miles per pound fuel × (aircraft weight pounds/2,370).

Assumptions

A jet engine has excess energy in the gas after the turbine $^1/_2(V_j^2 - V^2)$; this gas is expanded to atmospheric pressure and then has a velocity V_j giving a thrust of $V_j - V$ for each pound per second flow of gas. The complication of the thrust from a choked nozzle being slightly less than this value is ignored.

The propeller in the turboprop is assumed to have a propulsive efficiency η_p which does not change with forward speed.

Appendix 2

Ideal Thrust

The ideal thrust that may be obtained from 1 lb. per sec. of air having energy $^1/_2V_j^2$ is

$$(^1/_2V_j^2 - {}^1/_2V^2)/V$$

The actual thrust is $V_j - V$ and the ratio ideal/actual thrust = $(V_j + V)/2V$, which is the inverse of the Froude efficiency.

Turboprop

The turboprop may make use of the excess energy $^1/_2V_j^2 - {}^1/_2V^2$. This energy is distributed between the jet and propeller to give maximum thrust for each flight speed.

The thrust is given by

$$\text{thrust} = \eta/V\cdot{}^1/_2\cdot(V_j^2 - V_e^2) + (V_e - V)$$

where $\eta = \eta_t\eta_p$.

By considering V, V_j, and η constants, the thrust is differentiated with respect to V_e. This gives the condition that for maximum thrust

$$V = V/\eta$$

Using this condition and calculating the ratio of thrust to that of a jet engine exhausting to a jet velocity V_j, we have

$$\frac{\text{turboprop thrust for optimum conditions}}{\text{jet-engine thrust}} = \frac{^1/_2\eta(V_j/V)^2 - [1 - (1/2\eta)]}{(V_j/V) - 1}$$

Ducted Fan Engine

The ducted fan may use the available energy $^1/_2V_j^2 - {}^1/_2V^2$. This is distributed between the fan and engine exhaust to give optimum thrust.

If the ratio

$$\text{fan airflow/combustion chamber flow} = M$$

then there are two equations:

$$^1/_2(V_j - V^2) = \frac{M\cdot}{\eta}\ {}^1/_2(V_f^2 - V^2) + {}^1/_2(V_e^2 - V^2)$$

where $\eta = \eta_t\eta_f$ and V_f = fan exhaust velocity, and

$$\text{total thrust} = M(V_f - V) + (V_e - V)$$

Treating V, V_j, M, and η as constants, the optimum thrust is obtained when $V_f = \eta V_e$. Substituting in this condition and calculating the ratio ducted fan thrust for optimum conditions/jet-engine thrust, this ratio equals

$$\frac{(1 + \eta M)(V_e/V) - (1 + M)}{(V_j/V) - 1}$$

where

$$\left(\frac{V_e}{V}\right)^2 = \frac{1}{1 + \eta M}\left(\frac{V_j}{V}\right)^2 + \frac{M}{\eta\,(1 + \eta M)}$$

If the substitution for V_e/V is carried out, it is found that the condition for the thrust ratio to be 1 is $V_j/V = 1/\eta$, which is independent of M.

Optimization of Airplane and Engine Performance

By
E. F. Pierce

Speaking as an engine man, the word "optimization" always places me a little on the defensive. Not that optimization is not a desirable and perhaps necessary phase of the airplane and engine growth picture, but there have been so many cases within my own short experience where the limitations resulting from optimization have not been fully realized and where somewhat misleading interpretations result.

At any given time, optimization of airplane and engine performance would normally involve an assessment of the individual characteristics of each based upon some "use factor" whether it be a commercial operation or a tactical consideration. In such a study, an attempt would be made to evaluate the most desirable characteristics of the airplane and engine and establish the necessary compromises to provide the optimum combination. Application of the semioptimization procedure is seen in the many articles written on the turbojet vs. turboprop airplanes for commercial transport. In these articles, many factors are considered in addition to the normal items of airplane and engine performance. Such items as load factors, utilization factors, overhaul costs, and others too numerous to mention are considered and curves prepared to show the relative economies of the two methods of transportation. Despite the care with which such articles are prepared, there still exists a considerable divergence of opinion regarding the relative position of the two types of airplanes.

The example of the turbojet vs. turboprop airplane was chosen not to add an additional opinion regarding their relative merits but rather to show why optimization can be an extremely misleading thing. In the turbojet-turboprop studies, many assumptions must be made, and these assumptions have a great bearing on the resultant comparison. The items of hours between overhaul and cost of overhaul are, in themselves, sufficient to tip the scales in either direction, and there is little data on which to base sound conclusions for either item, particularly as applied to commercial operation.

Optimization has, however, even greater uncertainties than lack of basic engineering information. These two items might loosely be called the "time" factor and the "growth" factor. To revert to the transport previously discussed, one major consideration becomes immediately apparent when making a study and that is the state of development of the components to be considered in the comparison. Shall today's turbojet be compared with today's turboprop or tomorrow's turboprop? It is fairly well known that the turbojet development has proceeded at a much more rapid pace than that of the turboprop. It is likewise well known that much more efficient and economical turboprops could be developed than those currently available for airplane installation. Why they are not available is not a subject of this discussion. The choice of the time factor is, therefore, a major consideration in the optimization process. The time factor is of equal importance in optimization of tactical aircraft but for a somewhat different reason. For such a study, a future aircraft-engine combination will normally be under consideration, and the time factor must account both for the developments to be expected in the engine and aircraft and for the time differential that has always existed in the relative fabrication times. While it may not always be true, it has generally seemed that the prototype airplane can appear 1 to 2 years faster than the prototype engine. Thus, in optimization of tactical aircraft, the tendency is to use an engine in the analysis which will not exist at the time the airplane appears. Unless this time factor is recognized and properly accounted for, misleading conclusions can result.

The growth factor assumes importance because it is diametrically opposed to the optimization procedure. When optimization is used, the study should properly weigh the effects of changes in the items being considered such as the relative effects of engine fuel consumption, engine weight, etc. When making such studies for jet-powered aircraft, the effect of engine weight will be found to be of extreme importance with the magnitude of the effect bearing some relation to the airplane.

Various studies have indicated that 1 lb. of engine weight can be equivalent to from 10 to 15 lbs. of airplane weight when the airplane design is modified as necessary for the changes resulting from weight variations in the individual components. When the airplane is actually under construction, however, the effect of engine weight is found to be, in general, much less than the optimization procedure would have indicated due to consideration in the airplane design of growth considerations and, for tactical airplanes, a similar item that may be called "multipurpose usage." This, of course, occurs because the airplane will be designed to accommodate engine growth in thrust without necessitating a complete redesign of the aircraft structure. The design will likewise provide for other tactical usages, thus requiring stress considerations that are more stringent than the single-purpose design would necessitate. The growth factor is not to be considered as an undesirable thing, since the aircraft industry has progressed partly by full recognition of the importance of growth considerations. In an optimization procedure, however, "to growth" or "not to growth" may be the same as forgetting to divide by two or perhaps even by some larger number. As an example, the 10 to 15 lbs. of airplane for each pound of engine place extreme importance on engine weight. Were this number reduced to 2 or 3 lbs., as might be the case where the airplane design is not tailored to an optimized design, the emphasis might be placed more strongly on some characteristic such as specific fuel consumption rather than engine weight.

To sum up, optimization of aircraft engines is an extremely complex process at best. If all factors can be

accounted for, the process would be, of course, extremely exact. The unknown factors are of such extreme importance, however, that optimization serves more as an *area* guide than a guide for a specific design.

Optimization Studies on Propulsion Systems for High-Speed Aircraft

By

Abe Silverstein

From the vantage point of the last speaker of this panel on engine optimization, it is possible to recognize now, as all of you no doubt have, that there are many different points of view on the subject which reflect the occupations and preoccupations of those who present them.

The chief engineers on our panel, Messrs. Heinemann and Hall, have presented to us the practical view that must be developed by those responsible for the actual production of high-performance airplanes. They reflect what might be called optimization at the design level. Their emphasis was on the problems of engine size, installation, interchangeability, configuration arrangements, and other factors dealing with the practical problem of mating in the most satisfactory fashion the engine to the air frame. The importance of the practical outlook at the design stage was summarized most adequately by Mr. Heinemann when he said: "The consideration of practical aspects during initial design stages is most important and may actually shortcut a large amount of detailed and meaningless analysis, as well as developmental work. Essentially, the injection of practical aspects—if properly considered—should not discourage design studies but rather should shorten them and make them more accurate."

Optimization at the design level is normally circumscribed by necessity for the designer to use engines that are available to him or will be available at the time the airplane is completed. In his studies for maximum airplane performance, therefore, he must carefully explore all possibilities for utilizing and adapting available engines to provide an optimum configuration that will satisfy the flight plan that has been specified.

The engine designer who is to lead the way to new engines of higher performance must adopt another point of view somewhat along the lines suggested by Mr. Woods in his discussion. New concepts must be applied which lead to engines of lighter specific weight and higher performance. Questions must be answered as to the kind of engine that is needed to perform a given mission. What should the engine cycle be, and how can cycle concepts be introduced into an optimum production engine that will not only possess superior performance but can be manufactured in suitable quantities and will have the serviceability and reliability so needed in production engines? Some phases of these problems were presented by Messrs. Pierce and Dawson in their discussion.

In engine research laboratories, attention can be directed to even more fundamental considerations of engine optimization, since the laboratories are once removed from the pressures of practical production problems. The need for producing useful, as well as fundamental, information requires, however, that careful attention be given to the problem areas in which research is conducted and to the relative emphasis applied. As a guide for establishing the emphasis, a useful tool is provided by simple calculations that are based on the elementary laws of mechanics, aerodynamics, thermodynamics, and heat transfer. Following the steps outlined by Mr. Woods, calculations are made on many engine-air frame configurations to determine the relative importance of the variables in the problem of finding the best composite configuration to satisfy the requirements of a specified flight plan.

Many assumptions are necessarily introduced into the calculations, and the results of the analysis may certainly be questioned. With experience in continued calculations of this kind, the critical assumptions may of course be recognized and then be given special attention. By determining the change in performance resulting from widely different values of the critical assumptions, a satisfactory point of view is established regarding the meaning of the results. As my contribution to this panel discussion, results of a few calculations of this kind will be presented to emphasize some important optimization factors for supersonic flight.

Almost immediately after beginning calculations, one unassailable point of view is established. In supersonic flight, the propulsion system largely determines the kind of airplane performance that can be achieved. This situation persists even if different probable values of aerodynamic efficiency are assumed in the calculations.

The important dependence of supersonic flight performance on the propulsion system characteristics is shown most adequately by the results of Fig. 1, in which

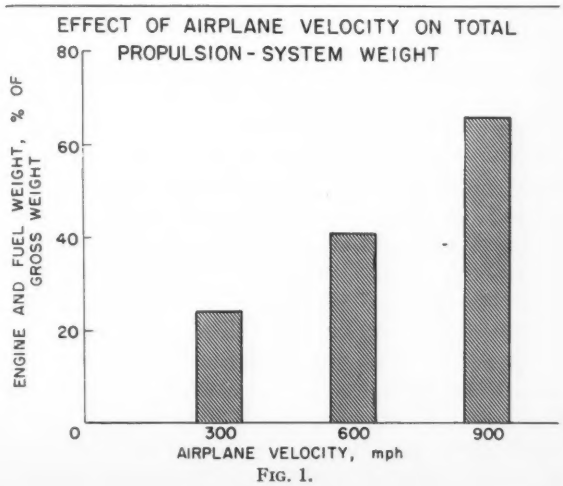

FIG. 1.

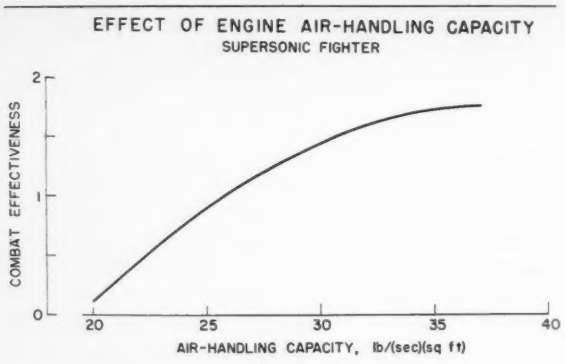

FIG. 2.

airplane velocity is plotted against percentage of the airplane gross weight represented by the engine and fuel. As the velocity is increased from 300 to 900 m.p.h., the percentage of the airplane total weight required for the engine and fuel weight increases from about 20 to around 60 per cent. Admittedly, the 60 per cent figure is approximate, and the value can be over or under 60 per cent, depending on the particular kind of airplane considered. However, the results show the order of magnitude of the change in the engine plus fuel weight with speed. Others on the panel have emphasized that the propulsion system and its fuel represent at supersonic speeds so much of the airplane gross weight that it is in this area of the problem that we can make big gains in supersonic airplane performance.

The supersonic fighter is a class of airplane which imposes particularly difficult requirements on the propulsion system. The fighter must fly fast, maneuver at high speed, and climb to altitude rapidly. To accomplish this mission requires the installation of as much thrust as possible into as light an air frame as possible. High aircraft thrust-weight ratios require correspondingly high engine thrust-weight ratios. The emphasis in the problem of the supersonic fighter mission must be directed toward obtaining lightweight engines, and some slight tolerance may be allowed on values of specific fuel consumption. We must look to see how the design of lightweight engines of high thrust capacity can be accomplished.

Calculations show some of the engine variables that are important. The effect of the engine air-handling capacity or the airflow per second per square foot of engine frontal area on the combat effectiveness is shown in Fig. 2. The ordinate "Combat Effectiveness" shown in the figure is a means for presenting the quality of the fighter performance on a relative scale and enables the points of interest to be established without recourse to detailed performance values. It is used on several of the following figures.

The results of Fig. 2 show that the combat effectiveness is almost doubled if the air-handling capacity of the supersonic fighter engine is increased from 25 to 35 lbs. per sec. per sq.ft. of frontal area. It will be extremely important, therefore, in our researches and in production engine to study and apply principles that lead to engines with high air-breathing capacity.

The calculations show next the relative significance of engine pressure ratio and engine weight on the performance of the fighter airplane (Fig. 3). A cursory look at the figure immediately discloses that the compressor pressure ratio is a relatively insensitive variable compared with the engine weight. In the calculations for the curves shown in the solid lines, the changes in engine weight with engine pressure ratio were disregarded. For the dashed curve (Fig. 3) marked "scheduled," the engine weights were estimated differently for each value of the pressure ratio, with the higher pressure ratio engines, of course, being the heavier. The "scheduled weight" curve shows even lower sensitivity of the fighter performance to pressure ratio than is the case for the less precise calculations. As mentioned earlier and shown in the results of Fig. 3, too great an emphasis cannot be placed on taking all possible steps to reduce the specific weight of engines to be applied to the supersonic fighter.

Elementary analysis is again of great help in the decision as to whether to add an afterburner to a supersonic fighter engine. The added weight, cooling problems, base drag for nonafterburning applications, and many other complications of the afterburner installations

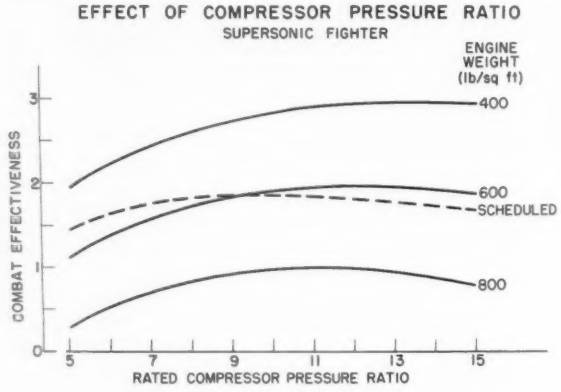

FIG. 3.

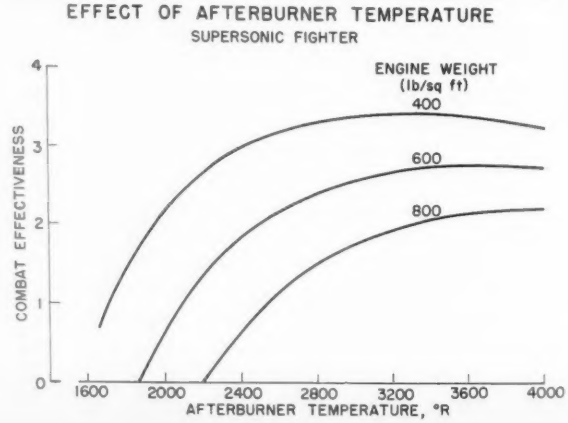

FIG. 4.

tempt the aircraft designer to eliminate it if at all possible. Results of calculations showing combat effectiveness against afterburner temperature with engine weight as a parameter are shown next (Fig. 4). The curves of Fig. 4 show the important gains resulting from afterburning in the heavier engines. Of greatest interest are the smaller gains shown for the light engine and the indication that the afterburning could perhaps be eliminated with only small loss in performance if values of engine weight per square foot of engine frontal area as low as 400 are reached.

An obvious way of decreasing the specific weight and getting more thrust from an engine of a given size is to burn more fuel in the engine combustion chambers and design for higher temperatures throughout the following hot portions of the engine. The many problems introduced in this design technique are well known to most of us and are the subject of researches in many organizations.

It was of interest to determine the temperature at which equal performance would be realized from a lower temperature afterburning engine and a higher turbine-inlet temperature nonafterburning engine when applied to the supersonic fighter. The results of a calculation (Fig. 5) show that the turbine-inlet temperature would need to be increased from 400°–500°F. for the nonafterburning engine to equal the performance of the afterburning engine. The goal of eliminating the afterburner by increasing the turbine-inlet temperatures is one that is well worth striving for.

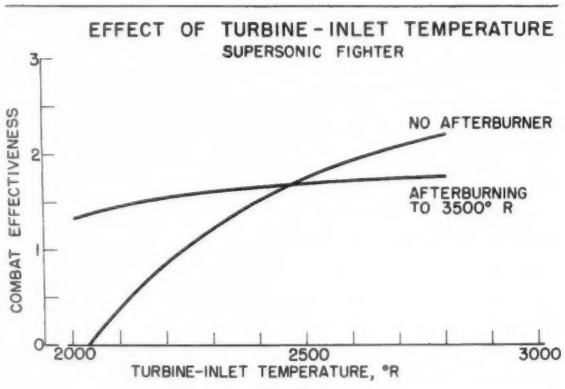

FIG. 5.

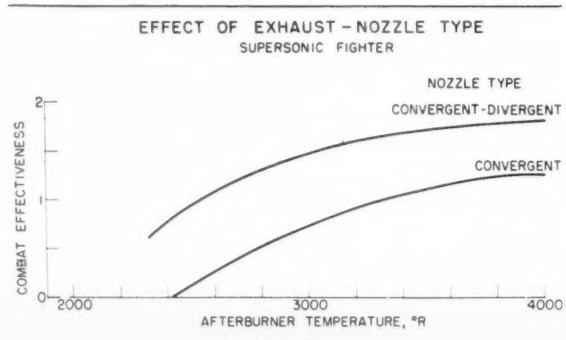

FIG. 6.

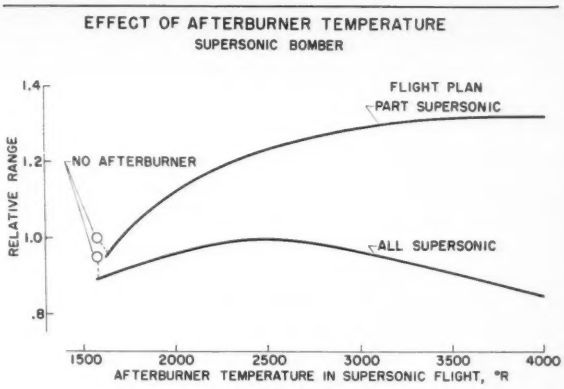

FIG. 7.

Another component that calculations show can importantly affect the airplane performance is the exhaust nozzle of the engine. The large gains from the use of the convergent-divergent supersonic nozzle instead of the simple convergent nozzle are clearly shown in Fig. 6.

To diversify the presentation and to show how calculations may be used for optimization studies on other airplanes than fighters, a few results are presented for a long-range bomber aircraft. For the long-range bomber, the engine specific fuel consumption becomes the preponderant variable usually overshadowing in importance the engine weight. As with the fighter, it is of interest to know whether an afterburner should be used as the long-range bomber and at what temperature it should be operated.

Results are shown (Fig. 7) for a bomber flight at supersonic speeds over the entire flight range and for the flight plan in which a part of the flight is at subsonic and a part at supersonic speeds. Detail results are naturally dependent on the exact flight plan chosen; however, for an arbitrarily selected flight plan, the results (Fig. 7) show that an afterburner would provide a useful result if only a part of the flight were accomplished at supersonic speeds but would serve no useful purpose if the entire flight were made at supersonic speed. The two points marked "no afterburner" near the left of the figure are reference nonafterburning values of relative range in which the afterburner weight and aerodynamic losses were not charged to the engine.

It may be of interest to mention an engine other than the turbojet. Thermodynamic calculations for rocket fuel are shown in Fig. 8 in which relative rocket range is plotted against rocket specific impulse. Values of calculated impulse for complete combustion of a number of possible rocket fuels are spotted on the curve. It is of interest to note that fuel oxidant combinations exist with range possibilities that are over twice those of the alcohol-oxygen combination that was used in the German V-2 missile. In optimization study of long-range missiles and in selection of rocket fuel-oxidant

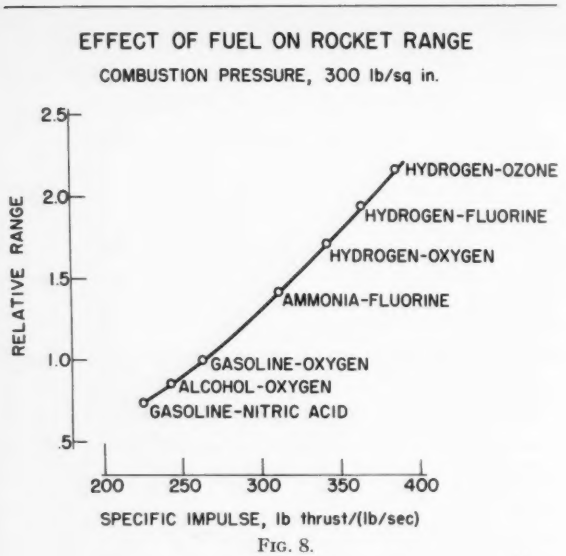

FIG. 8.

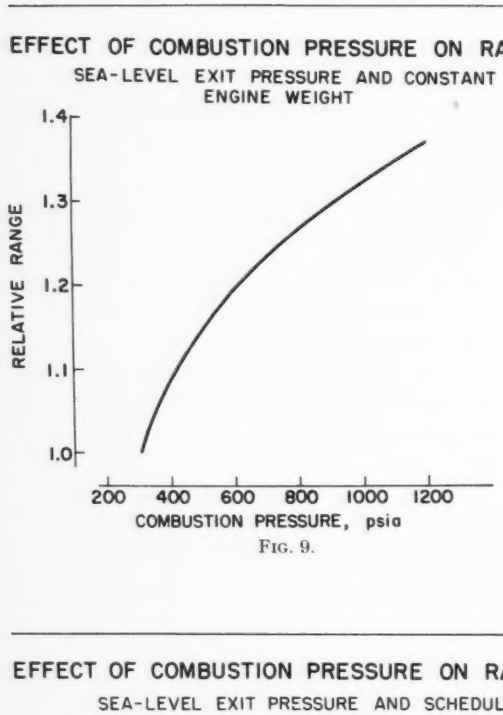

FIG. 9.

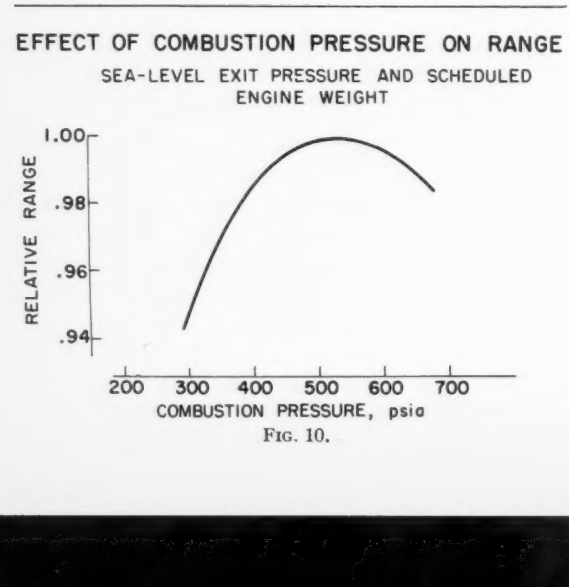

FIG. 10.

combinations for study and development work, considerable attention needs to be given to the results shown in this simple chart which were obtained from thermodynamic considerations without recourse to any experimental data.

To temper my discussion and to illustrate some of the errors in the conclusions that can be drawn from too hasty acceptance of the results of simple analysis, results are shown (Fig. 9) in which the rocket combustion-chamber pressure is plotted against the relative range. The results show increasing values of the relative range with increasing combustion-chamber pressure for all values shown on the curve. In preparing the results of Fig. 9, the untenable assumption was made that engine weight did not vary with combustion-chamber pressure. If it be assumed that the rocket-engine and pump weight increase with combustion-chamber pressure in some reasonable manner, the results of Fig. 10 are obtained.

It will be noted (Fig. 10) that there is a peak value of relative range. The effects of increased engine weight outweigh the gains from increased rocket-engine cycle performance. If less conservative estimates of rocket and pump weight are made, the peak pressure can be shifted to a higher value.

Optimization studies need to be made cautiously and their results used with judgment. By combining all the talents available in research laboratories, industry, and military services, it should be possible to make optimization studies of a most fundamental character which could be adequately tempered with the practical considerations. In this way a sound program for the future could be achieved. I say "let us be about it."

Discussion

Chairman Taylor: We did a lot of optimizing, and we covered a tremendous amount of area. I am sure there are details that were omitted, because, really, we only set up an outline for optimizing. So, any of you who have questions may present them now.

Waldo Claflin, *Grumman Aircraft Engineering Corporation:* Sometimes a basic engine type may have optimum design and efficiency characteristics for an airplane application but may not be available in a size that suits that application. I would like to ask whether it is practicable to produce an engine of good basic design in various sizes to meet the size requirements of various aircraft.

Chairman Taylor: Could we ask the question a little differently? Could we ask, "How practical is it to scale the size of an engine when the type is established?" In other words, is that as hard as making the engine over again, or is it easier if you scale the type of engine?

Mr. Claflin: Yes I would like to know whether it can be done and, if so, to what extent it should be done.

Chairman Taylor: I think we had better ask Lindsay Dawson of Rolls-Royce.

Mr. Dawson: Looking back over the history of our operation, it is true that we have done one successful scaling operation in producing a new size of engine from an old size one—the Derwin-5 centrifugal engine. I think it came out rather a better engine too, but my feeling is that it is not a general procedure one can follow. I think it was easier to do this in the case of the centrifugal engine that had simpler components.

You certainly cannot guarantee you will not get a different set of mechanical problems if you scale an engine either up or down. So many of one's mechanical troubles are vibration troubles that depend upon the absolute size of the engine. Of course, you never really do scale it; you always alter it a bit on the way. When you come to the axial engine, I think one can say that if you scale it either way, from the development point of view, you have got a new engine to develop, and it is, naturally, as hard as the original one. It is not at all certain that the best engines remain the best engines when you scale them up and down. For example, on the question of engine specific weight, there is certainly an effect connected with size. You can make engines of a better specific weight by either making them small or large (just at this moment I am not sure which it is myself), because the engine auxiliaries and control system tend to be independent of the size of the engine; so that, when you have a small engine, the weight of the auxiliaries tends to remain constant as compared with big ones. On the other hand, the specific weight of the rotating parts of a small engine are better than a large one.

The simple answer is, there is no advantage in scaling one engine from another; you have to treat it as a brand-new engine. Certainly from the development point of view, you will have just as much work to do, and the problems between the two engines are likely to be different.

Mr. Pierce: I concur completely. The further point is, of course, the time cycle is completely out of phase if you have to take an old engine and start to scale it and have to wait another 3 years to develop it. You can never have the rigidly established standard engine and make a scaled engine that will be better.

Chairman Taylor: In other words, the scaling implies a static condition while you are changing its size; and there is no such thing in this industry, because, by the time you get it scaled, you want an improved engine, not the engine you started with. Do you both think that this is so?

Mr. Dawson: I would like to end up asking why they do not scale the airplane too?

Chairman Taylor: We will have to ask the rest of the panel about that.

Mr. Pierce: I might add from the engine manufacturer's point of view that, if you look at a design competition for a specific airplane mission, you will notice an extreme variation in airplane size. I have seen tremendous variation from 14 to over 30,000 lbs. for the identical mission requirements. As Mr. Dawson says, there might be a little more attention paid to the size of the airplane rather than to the multiplicity of engines.

T. P. Wright, *Cornell Aeronautical Laboratory, Inc.:* I feel that the concept Bob Woods gave—of trying some way to give engine development a head start over the air frame to which it was going to be assigned—is one of the most basic problems we have in this country. I would like to find an answer from the engine people as to whether this scheme appears practicable. To summarize my concept of the scheme, it is to match mission and ideal engine, following possibly some of the techniques of Abe Silverstein first, and arriving at what would be an optimum engine for the general mission of a class of aircraft; then, to start an engine development for the proper size and configuration to meet that mission need and let the engine manufacturer proceed for two years when he might have a first engine for preliminary running. If it appeared it was going to be successful, or had potentialities, then match that engine to a suitable air frame. Don't try to match the air frame initially and have the sad experience of winding up with an air frame and no engine ready for it.

If any of the engine manufacturers would comment on Bob's scheme, it would be interesting.

Mr. Pierce: Well, of course, it could be put into effect at any time if the aircraft industry were satisfied to take the engine that is currently running. That does not seem to be the case. In fact, the trend today, I find, is that normally not only is the airplane based on the engine you are going to have but it's partly based on the engine you are going to have beyond that. So, I believe we are being pressurized by external sources to keep from starting the engine ahead of the airplane—as Mr. Woods proposes.

S. Scott-Hall, *Research and Development Branch, British Joint Services Mission:* I find it difficult to put this in the form of a question. I think it might be interesting to make a comment and perhaps Mr. Dawson might challenge it if he does not agree with it.

We in Britain have tried to do just what Mr. Woods has been advocating, and I think we have achieved some measure of success. We are helped greatly by geography in that the whole "time discussion" is going on continually between the aircraft designers and the engine designers to see what kind of engine is really going to be required in the next generation of aircraft and beyond that. It was my function in my last job to try to bring together the two sides—to try and tide over this gap that clearly exists in time when starting an engine that will be needed for the next generation of aircraft.

Now, the difficulties are considerable. One of them is the psychological one. Aircraft designers are prima donnas, and they would not be good designers unless they were. They have pronounced views, and the scaling question that was asked is one of the things which always comes up. Nevertheless, I wanted to make this comment, and perhaps Mr. Dawson would tell us if we have achieved some plan of campaign to try to do just what Mr. Woods is advocating.

Mr. Dawson: I agree with Mr. Scott-Hall. It is certainly true that at home the aircraft and engine planning seem to go in parallel. You do have to allow for a certain difference in the time scale, and, to that end, I think the MOS has been pretty successful in bridging the gap.

Mr. Scott-Hall: There is one other comment I would like to make. It has always been the practice in the United Kingdom not to specify at all closely the requirements or specifications of an engine. It is left as fluid as we can possibly leave it so that the aircraft designer and engine designer can settle it between themselves.

Fredric Flader, *Fredric Flader, Inc.:* Mr. Hall has emphasized the importance of small diameter, and Mr. Silverstein has stressed the importance of weight. These two things may not be entirely compatible. It seems to me that the only way the two can be reconciled is by thorough study of the engine and the aircraft in which it is intended to be used. Further examples of that general nature can be cited. For instance, consider the importance of the air intake system and the exhaust system, neither of which can be initiated and carried forward to a conclusion by the engine designer completely.

I remember, in many years' experience in designing aircraft, we were always handed a group of drawings from the engine manufacturers and shown mock-ups. We then had our choice of those engines that were on the market, or were intended for the market, and we had to make the best airplane compromise we could—selecting the best of those engines.

So, I am in somewhat disagreement with Mr. Woods wherein he advocates an engine study coupled with an airplane mission study, without going into greater detail. I do not see that we can build an engine that could be put into a monoplane, bat plane, or biplane, without considering these other factors that may vary from one airplane's concept to the other and one airplane manufacturer to another.

Therefore, it seems essential that airplane designers and engine designers get together early in the game and decide which is the best engine configuration from a technical study of both problems. Then the engine manufacturers could be given a 3-year start.

Warren Joy, *General Electric Company, Aircraft Gas Turbine Division:* I would like to make a comment in answer to Mr. Wright's question. (He asked whether engine companies in the United States were following Mr. Wood's suggested program.) I would like to say that our Product Planning groups have been doing this for the last 2 or 3 years on a limited scale. We have found that the method of combining aircraft mission data, hypothetical aircraft data, and general engine cycle data has proved to be extremely useful in the preliminary phases of our gas-turbine designs.

In fact, I believe one of our latest engine projects was conceived on this basis. Other newer projects now under way are being carried out using this method of attack also.

Abraham Moskowitz, *Air Materiel Command:* I am a little lost at Bob Woods'—I will not say criticism—suggestion of the apparent lack of correlation between the work of the engine manufacturer and the airplane designer. There is a certain engine I am quite familiar with, and I happen to know that the airplane designer and engine manufacturer actually got together some 2 years before the engine was running. I might add also that the engine manufacturer gave the airplane manufacturer the configuration of the engine, the thrust, and the specific fuel consumption, and, in each case, they were considerably ahead of their predications when the engine was finally delivered.

I mean, I think there is such a thing. Now, of course, there is a certain change in the aspect that I think we have to consider and that is whether R & D was separated from AMC. The original idea of Jimmy Doolittle, who was the father of the idea, was to do the very thing you are talking about. I think you remember at that original time that R & D was expected to figure a project 3, 4, or 5 years in advance—including both engine and airplane—and tie the manufacturers together. I think they are working along that line to some extent. Now, whether they are entirely perfect, I don't know.

While I am here, I want to question the engine manufacturers. There are two things I would like to know: (1) What is compressor blade flutter? Is it aerodynamics? Mechanical? (2) What is pulsation or surge, and how do we eliminate it?

Chairman Taylor: Would you like to say something on that subject, Abe, or do you think it will lead you too far afield?

Mr. Silverstein: Why don't I get together with Mr. Moskowitz? It is a rather lengthy and complicated subject, and, you recall, last year at this time our meeting was entirely devoted to this subject. I think we ought to get together and talk this over at length. I will discuss it briefly if anyone else is interested in it.

Chairman Taylor: I think we had better stick to optimizing rather than fixing our basic troubles for the minute.

Question (*from the audience*): On the question of getting the two together, would this system of management, of which we have one or two examples, help the situation? Is it as simple as management control, where one commercial outfit has control of one-system-airplane-power-plant control all the way through? Is that oversimplification, or is that a step in the right direction?

Chairman Taylor: Let us say a word about what happens now. I think the power-plant people and the air-frame people are extremely close together. They talk to each other frequently and have talked to the military frequently. The power-plant people are inclined to direct their major energy to the area in which they think the major procurement is going to lie. And since they are impelled by exactly the same forces, they are all inclined to land in the same place. So that, instead of a list of engines over a series of sizes, or

series of types, you are inclined to get four or five in the same area. That area is then parceled out to airplanes —depending on a lot of things. Then the engine people want to develop something new, so they again apply the same principle and find themselves in the same area, because they are analyzing the same factors. I think some degree of control or some degree of connection between an engine company and a specific airplane development might tend to move this thing over just a little bit.

I am not quite sure whether yours was in the form of a question. You said, "Would that help?"

Interrogator: Yes, I was interested because there are a few systems now out on contract on that basis.

Chairman Taylor: We will let Bob Hall take a crack at that one.

Mr. Hall: I will answer that by saying that we feel about engines as we feel about electronics, armament, and other components that go into the completely developed airplane. We feel that the overall result is likely to be better if we have no financial or administrative involvement in producing such components. To be specific, we are quite sure that if two or more independent engine manufacturers are competing for our business and we are able to accommodate their engines interchangeably, the end product of at least one manufacturer is likely to be better than anything we might produce by ourselves, without competition.

Chairman Taylor: Ed Heinemann, you had some recent experience in rather complete control of a project. How did you like it?

Mr. Heinemann: Generally, I feel the system we have in this country is good. We have five competitors capable of developing good engines, and the competition will keep the engine development at a good rate. Personally, I think we have too many engineers trying to do system analysis work and not enough doing good engineering. Personally, also, I would not like to take on the responsibility for engine development. I think the engine people with their background can do a better job than the air-frame people can do—even though we have taken on the development of many other components such as actuators, bomb racks, etc. We didn't especially want to take these on but did so only because we couldn't get a good job of engineering on the outside.

I don't think a system management approach would do anything but confuse the issue.

Mr. Moskowitz: Remember General Putt's paper on weapon systems? It was only presented a year or so ago, and it covered that very thing, but the concentration lay in R&D. That really answers his question.

Mr. Wright: This question is directed to Mr. Dawson. We were speaking a minute ago of using the same basic engine scaled up. I'm now talking about scaling up one little part of that engine—that is, to change the by-pass ratio in the by-pass engine by amounts so as to optimize for various speeds. Is it possible within reasonable limits to change the by-pass ratio with the same basic engine?

Mr. Dawson: When you come to read a paper at this sort of meeting, you always cheat. You oversimplify to the point where everybody thinks you've got a nice cut-and-dried story to take home—except the people who are more expert, who know perfectly well you're just pulling their leg. When I was talking about the by-pass engine, it was a gross oversimplification, because, if you change the by-pass ratio, you change the diameter of the engine and the drag of the installation. You have to find out where you put it; and, in spite of opinions to the contrary, the weight of the engine is extremely important, even on quite long-range aircraft; so you have to bring in the problem of weight, etc. The first thing to decide is whether you really want to change the by-pass ratio. That is a simple, overall sum, and you can only do that with a particular study on a particular aircraft. If you conclude you do want to change it, you know perfectly well in any normal sort of engine it is never quite as simple as it looks, and you find you have upset the overall balance of the system and have saddled yourself with a much larger job than you suspected.

For example, if you change the by-pass ratio, you change the amount of power needed from the turbines; and you may have to change the number of turbine stages in the engine.

T. F. Cartaino, *Allison Division, General Motors Corporation:* In this optimization topic, Mr. Woods, when we come to the final evaluation of these air-frame-engine combinations, are we still justified in using as a perimeter this business of the least gross weight that will give us the required mission?

Chairman Taylor: For the airplane?

Mr. Cartaino: Yes.

Mr. Woods: You want to assume a conservative value that is reasonable of attainment. Your assumptions should be representative of current or predicted state of the art and know-how at the time you contemplate this thing will happen. You want to make reasonable assumptions and not the absolute minimum.

But I think, about as I anticipated, at least some of the people in the audience have missed my point—that is, my argument that I don't want to get the air-frame and the engine people together in initial concept phase of the engine development. I want to keep them apart, because I feel that, particularly as we pass into this supersonic speed area, perhaps the engine and the fuel system become such a major part of the whole that we will want to optimize the power plant. I have been more or less avoiding saying that the power plants we have do not incorporate improvements that are representative of our current apparent scientific and technical know-how. We do not yet have the high turbine-inlet temperatures and air-cooled buckets we should have. Maybe the Americans are waiting for the British to come up with something that they can copy.

I am in the hope that, if we air-frame designers remove our benevolent influence, when the engine designers get to looking the problem directly in the face,

they will arouse from their lethargy and go out and do something about it—something drastic.

George C. Rapp, *General Electric Company:* Along this line of working together, several years ago I think that it was the opinion of almost all aircraft manufacturers that they wanted to do the aerodynamic job of the inlet. Now I think perhaps with the advent of supersonic flight it is time we re-examined this and asked the question, "Can the air-frame manufacturer do the job alone in the supersonic range?" In the supersonic range it appears this will not be the case. There really will have to be an extremely closely knit alliance in the development of the engine and the air-frame combination.

Now, I would like to pose a question to the panel. Do they believe that this is necessary?

Chairman Taylor: Does the panel believe that it is necessary to have a close alliance between the engine and airplane manufacturers in developing the inlet for a supersonic airplane?

Mr. Hall: I think it is most certainly desirable. I believe I implied this earlier when I said that the engine designer should know internal as well as external aerodynamics. While my emphasis at that point was on the afterbody configuration, I am sure that close cooperation on the inlet design is of equal importance. The trouble is that the configuration of the inlet is so influential in governing basic arrangements for the particular aircraft that we don't feel we can have this work handled by the engine people alone. I agree, however, that they should be thoroughly conversant with all the problems.

Chairman Taylor: Would it be reasonable for you to design it, and then have it checked when you have it designed?

Mr. Hall: That is exactly what we do today. We supply our entire intake system to the engine manufacturer for test, and I'm sure we've gained much thereby.

Chairman Taylor: Bob Woods, do you want to say something about that?

Mr. Woods: Of course, we're talking about a wide range of time, place, and circumstance. Subsonically, I think our technicians well warrant the continued support and all the enthusiasm that we can give them. But, I'm still maintaining that supersonically the power plant becomes so vitally controlling in the whole picture that, outside of a little freedom in wing configuration perhaps, the rest of it is all established for us. It's going to be sharp, thin wing or it isn't supersonic, and that's a basic perimeter. So, in a supersonic configuration of moderate range, the engine air inlet condition design variation can influence the range something like 15, 18, or 20 per cent, from bad to optimum. It's therefore obvious that we ought to strive in our concept of designs for the maximum optimization we can get in the power-plant system and presume it can be attached to an air frame of suitable capacity and capability later on.

It's all a question of degree. Such divorcing of the engine concept, tying it directly into the requirements, mission, and concept stage, would have to be supported by direct collaboration between engine and airplane people in final development and actual construction of installation, obviously.

But, my point is still that in the concept stage we ought to see—well, perhaps I can use an analogy. A naval gunner needs practice shots to bracket the target. Admittedly, it is wasteful to fire one over and one under the target, but, in so doing, they establish a range for a hit on the target.

Because supersonic projects and engine developments are extremely expensive, time consuming, and limited in number, we want to be sure we get the right answer. The best way to do that is to bracket the situation by an optimization study that includes an assumed air frame of some reasonable concept and see whether we land in the straight turbojet, ducted fan, by-pass, rocket-ram-jet, or a combination arrangement of engine types.

We should try to find the general range of possibilities during the general concept work. At that stage of the game, I can't see that the average airplane designer can contribute more than confusion—because, unfortunately, we are stuck with problems of our own. In some cases, we have a company configuration commitment in the airplane, and the company says, "You sell it even if it isn't any good."

At that stage of the game, I think perhaps it's best that the engine people find their way in the wilderness without our benevolent help, as I pointed out before.

Hans Schmidt, *Wright Aeronautical Division, Curtiss-Wright Corporation:* In the early days of jet-engine development, 1938–1939, half the country considered that it was always necessary to have extra thrust maintained during take-off. Nowadays, it seems it's equally important to race at maximum speed. I would like to know if take-off cruise is still as important as it was in those days, or if you might make a sacrifice and by so doing get better elevation.

Mr. Heinemann: I might say that in the last three or four jet designs we have worked on we have not found take-off boosters necessary. If the airplane is going to have good maneuverability at altitude, it usually has enough lift to get off, even from a carrier. Then auxiliary boost is not necessary, except in one case I know of where catapult limitation requires it. But, afterburner boost for take-off doesn't seem to be too important, except, perhaps, for some interceptors.

Mr. Schmidt: What would you say if I could give you a power plant that weighs very little or practically nothing? Would you be able to use such a power plant with, say, a specific weight-size ratio of 0.25 or even less? Of course, that means putting the power plant in the tail end as far back as you could go.

Mr. Heinemann: Offhand, I would say "no" because, in the first place, it's extremely difficult to get proper balance in the airplane with the power plant aft. If you notice, all current jets have power plants forward, either at the center of gravity or foreward of the center of gravity.

Mr. Schmidt: Would it make a difference if the power plant were very light and very concentrated?

Mr. Heinemann: Well, I think not. I think, if you have enough thrust to take care of the maximum speed conditions, climb, and everything else that is required for a combat machine, it will have satisfactory take-off characteristics.

J. F. R. Floyd, *Johns Hopkins University:* The discussion of turbine engines has been tempered by the consideration of practicality. I would like to ask Mr. Silverstein if he would make some comments on the practicality of rocket fuels he mentioned.

Mr. Silverstein: I don't think I can make any comments—I haven't been building rocket engines. We don't have a man on this panel who has had that experience.

T. J. McGuire, Jr., *United Aircraft Corporation:* I wonder if I detect a bit of conflict in what Mr. Pierce and Mr. Woods had to say. Although Mr. Woods pointed out that at supersonic speeds the importance of the aircraft seems to be on the order of 5 per cent compared to 15 or 20 per cent for the power plant, Mr. Pierce pointed out that in design competitions (or in one case he knew of) there was a gross weight variation of from 14,000 to 30,000 lbs., presumably using somewhat the same engine.

I was wondering what the conflict in my own thinking was.

Mr. Pierce: There is not as much conflict as appears on the surface. In that specific case, they were not using the same engine. It went from a very small engine with the barest essential equipment to a much larger engine and more complex airplane having more flexibility. So, the conflict is not what is required to do the mission but what else you want to have the airplane do after it has successfully completed the mission.

Chairman Taylor: It is a relatively small variation in mission making relatively larger variation in the configuration and size of the airplane, and I think that can't be exaggerated.

Thomas Barnes, *Grumman Aircraft Engineering Corporation:* I would like to ask Mr. Dawson if he believes the by-pass engine with afterburning turbojets is necessary for normal supersonic flight?

Mr. Dawson: I am a great believer in Abe's sums, and I should hate to answer the question without somebody doing some rather careful calculation. You have said "an afterburning engine for supersonic flight." This brings me to a point—having listened to one or two people.

I think Abe touched on this in his paper. I don't understand why everybody assumes you must have an afterburner. First of all, we have never needed afterburners for take-off. This is a product of the local type of aircraft design in the United States. Secondly, it always seems to me that for some applications, if only we were clever enough and could get enough thrust into the airplane by making the engine light enough, we might be able to do without the thing.

Personally, I think it's an invention of the devil.

Mr. Douglas, *North American Aviation, Inc.:* I would like to ask Mr. Silverstein if he doesn't believe that the divergence-convergence air nozzle would not be an interesting possibility (somewhat of a necessity of supersonic flight), because engine limitations are going to become more difficult, and more efficient use of the engine will become necessary. I know at North American we did a preliminary study on the effect of convergence-divergence nozzle and of a variable air nozzle and found the results most promising.

Mr. Silverstein: I think my curves on Fig. 6 showed that.

Question (*from the audience*): In the consideration of optimum performance either of power plant or of the air frame, I should think it would be wise to consider the possibilities of rocket propulsion both for jet take-off and also for superperformance when the American aviator finds himself more or less low man on the totem pole under a cloud of enemy fighters.

Don't you think this could possibly supplant the afterburner to give you additional thrust? I would like to hear from Mr. Heinemann, since he made a remark about the afterburner.

Mr. Heinemann: My personal opinion is "no."

The discussion was concluded at this point, and a movie was presented by Mr. Heinemann.

The Flight-Test Organization

F. E. CHRISTOFFERSON*
Northrop Aircraft, Inc.

SUMMARY

Most design engineers are not in a logical position to maintain an open-minded frank approach to flight testing; they cannot achieve a wholly objective analysis of the results of their own work. Flight testing is, in a sense, an evaluation of engineering work and must be made by someone other than the design engineer.

The more general postulate is that those who are concerned with the quality of an airplane in any of its phases must not be subordinated to Engineering, Manufacturing, or Sales. They must have a clear pipe line to "top management" unimpeded by the subjectivity of the major operating functions. The "Quality Control" function has historically had separate reporting privileges but has been confined to the inspection of manufacturing only. Those who are technically qualified to evaluate the in-flight quality of the airplane have not always had this privilege; they have too frequently been subordinated to Engineering or Sales. Too frequently the practical judgment of pilots and others experienced in the operation of the product has been lost in a forest of specifications, "mission concepts," "established requirements," and scientific double talk.

It is on this basis that we argue that the flight-test function should be independent, distinct, and complete; reporting equilaterally with, not through, any major operating function of the company.

INTRODUCTION

DURING A DISCUSSION of certain phases of flight testing as they relate to Engineering, it was suggested that I present my arguments in a paper. The discussion centered around the degree of participation to be expected by either technical or design engineers in the analysis of flight-test data. The discussion was part of a larger argument about the functions and the organization of Flight Test, the course of its development, and its improvement. For the purposes of this discussion, I will only go back to 1941, illustrate the thinking current at the time, and connect it with both the present situation and the growing belief that flight test should be independent, distinct, and complete, reporting equilaterally with, not through, any major operating function of the company.

BACKGROUND

In 1941, Flight Test was generally organized under Aerodynamics or under a common head with Aerodynamics. Most of the work that was required of Flight Test was aerodynamic in nature: performance, stability, and control. The performance testing was primarily the only quantitative testing done, and even that was from data recorded by hand by the pilot or the flight-test engineer. Stability and control testing was an art of the engineering test pilot upon whose judgment and knowledge frequently depended the entire evaluation of the handling characteristics of the airplane. Aerodynamics regarded this person as a psychological curiosity, full of opinions and half-truths. They were forever probing to find why he wanted lateral stability, why he wanted the aileron forces to be proportional to rolling velocity, why he insisted on positive longitudinal stability but lower trim changes with speed.

To illustrate this organization and the basis upon which it was formed, I have drawn upon the 1941 flight-test manual of one of the major aircraft companies for its organizational chart and a quotation giving the reasons supporting it:

"Flight testing may suffer from its inherent location in the company's organization as a whole. It is well known that the flight-testing groups in some companies have been with the Sales Division, the Production Division, or operate from some other division only remotely associated with the engineering and design groups. Obviously, no amount of individual integrity can, with such a setup, yield optimum results from a design standpoint. The Flight Test Unit must fit into the general organization in such a manner as to enable close coordination with Engineering, Aerodynamics, and other Design Groups."

An important inference may be drawn from this quotation: The flight-test organization was in a state of change, and, even though settled momentarily at the beginning of this critical period, its exact location within the company was unsettled. Two definite opinions are expressed as reasons for this organization: (1) The integrity of the flight-test function as it supports the design function is impaired if Flight Test is organized under Sales or Manufacturing; and (2) the flight-test organization should permit close coordination with Engineering, Aerodynamics, and other design groups.

Fig. 1 is the organization chart of this same flight-test organization from which the quotation is taken. As you can see, the Director of this organization was also in charge of the Aerodynamics Department, and, as you probably all recognize, this was a familiar pattern in most aircraft companies during the early years of World War II. Under this organization it was only natural that the priorities of the work done in Flight Test should favor Aerodynamics. Stability, control, and performance were the subjects of 90 per cent of the work done. Hydraulics, mechanics, and electrical systems and actual structural development testing.

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* Chief of Experimental Flight Test.

armament testing, etc., took a second place to the phugoid oscillation.

This was the era of the sequence valve and the sticky relay. During this time "working the bugs" out of the airplane was the accepted task of newly formed squadrons and commercial operators. Underdeveloped electrical and electronic installations produced service maintenance nightmares. Hydraulic and mechanical systems had minds of their own. Landing gears were both up and down at the same time. Bomb bay doors would open or close, but they would not do both during the same flight. It was in this atmosphere that the postproduction modification centers evolved. Hundreds of assemblies were scrapped, re-engineered, and rebuilt. The "retro-fit" became an institution.

I am not implying that any short-term or long-term answer exists which will resolve the problems of underdevelopment. I am saying that the recognition in the aircraft industry of its responsibility with respect to the whole airplane has led to a functional and organizational growth that, as part of this growth, has altered the functions and organization of Flight Test.

The requirements for flight-testing the other areas of the airplane which were restrained by the 1941 organization produced a change where Flight Test reported directly to the head of a technical department or subdivision that included Structures, Dynamics, Thermodynamics, Armament, Electronics, and the various system installations groups. In some cases, Flight Test was organized on a departmental basis reporting directly to the Chief Engineer. (See Fig. 2.)

But, even under this organization, relations with the Project Office, the Sales Division, and the Manufacturing Division were somewhat ill-defined and poorly coordinated. Schedules were relatively loose and uncontrolled; lack of timing was most usually a sad fact about which there was a great deal of rationalization and no active planning. "Academic testing" and "researching" became accusations legitimately directed at most flight-test organizations by production-minded project and manufacturing people.

Further, the "integrity" that was questioned in the organization under the Sales Division because of its primary interests in selling and under the Production Division because of its primary interest in schedules and costs was now being impaired by the equally subjective interests of the design or technical engineers: The design engineer wanted Flight Test to prove the first premises and assumptions used in the design; they preached a "positive" approach to flight testing; "prove the airplane to its specifications; use it as it was intended to be used; we will take the responsibility for the risk that the airplane will *not* meet the competition."

This organization remains a relatively general situation in the industry today. It cannot fairly be argued that it will not produce good results. Tremendous strides have been taken in the development of airplanes during the years the various forms of this organization have been in force. And, certainly, this organization has not deterred this development in the cases where

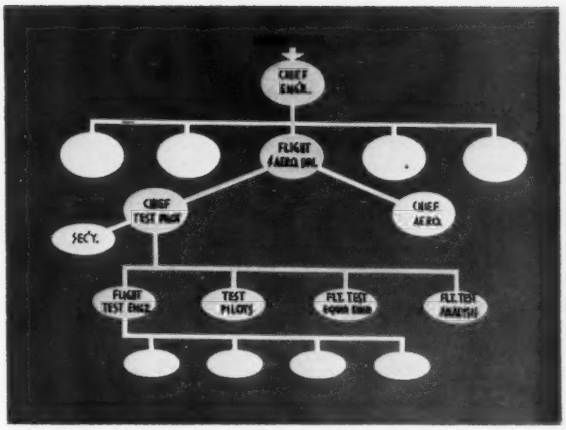

FIG. 1.

progress has been made. It has provided the design engineer with a practical development tool. In many cases, it has provided him with information that he could not otherwise obtain. Nevertheless, during these same years—and now—the customer has not been wholly satisfied with the airplanes' development; the results have not been *all* good. There have been criticisms and, in the worst cases, cancellations. Ordinarily, where criticism has arisen, it has been preceded by criticism within the company made by the pilots, the flight-test engineers, and the crew operating the airplane.

Many of these criticisms could have been avoided. When they were reported to Engineering by Flight Test they were received as "isolated cases," "marginal issues," "outside the scope of the design," and "conclusions based on insufficient data or based on too much scatter." Many times the problem was recognized too late to be corrected.

Some companies have looked upon this flight-test reporting as a significant preview of their customers' reaction. The management of these companies has redelegated the flight-test responsibility so that the Flight Department reports directly to management. It has made the Flight Department responsible for the evaluation of the airplane and responsible to Engineer-

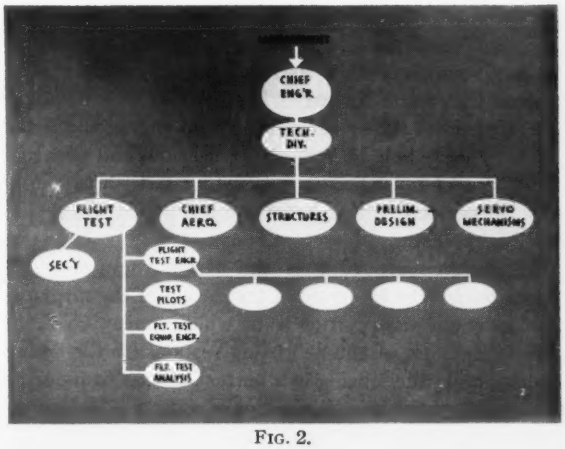

FIG. 2.

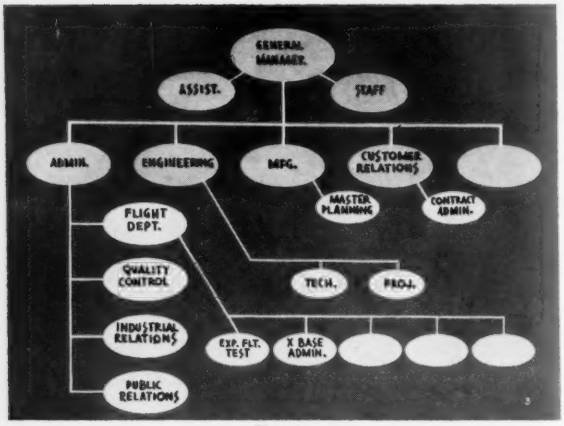

FIG. 3.

ing only as a service function supplying technical information in support of design and development. (See Fig. 3.)

THE FLIGHT-TEST POINT OF VIEW

I recall a conversation with Tommy Booth who at that time was a Commander in the Navy and the Director of Flight Test at Patuxent. We were discussing the development of *quantitative* flight testing, the use of recording instrumentation. He was concerned with the possibility that, with this development, test pilots would lose their perspective; that they would lose the freedom of their own judgment in the *qualitative* analysis of the airplane. He was concerned that the numbers, the measurements, would become ends in themselves and that their meaning would become secondary. The point of my recalling Tommy Booth's remarks, however, is that it illustrates his respect for a point of view that should be an inherent part of the evaluation of the airplane. The developing judgment of the people operating the airplane, conducting the tests, and evaluating the results should not be impaired by the authority of a number. It should be included, recognized, and made part of the personnel asset of the company.

It is only fair to the people who will eventually use the airplane to include the perspective of Flight Test in the functions of the aircraft company. This perspective must make the integrity of the airplane in both its complete sense and its objective sense the essential purpose of testing. The aerodynamic airplane, the air frame, the systems, the components, the detail parts; their whole operation, application, and eventual environment must become one integrated whole. And this integrated whole must be examined frankly—by Flight Test.

It is acknowledged that the design engineer is responsible for the integrity of the design of the airplane. But he is not in a position to be wholly objective about it. It is a case of the hen being responsible for laying the egg and others being in a better position to judge it. The design is the function of Engineering. The evaluation is the function of Flight Test.

This organization establishes Flight Test as a function that is no longer an exclusive part of one department, one subdivision, or one division. Flight Test can now reacquaint itself with the services it performed at one time for the Sales and Manufacturing divisions. The demonstration of an airplane is a primary tool of the sales people, and I do not mean demonstration in its structural demonstration sense. Flight Test should be prepared to fly the airplane for sales as a matter of course. It is Customer Relations that encounters the questions about the use of the airplane and about all the operational "ologies" that are common to pilots the world over. In its turn, Customer Relations is a source of information for the pilot and the flight-test engineer. It provides continuity and a fresh knowledge about the mission and the exact conditions under which the airplane will be used.

The effect of flight testing upon the production of the airplane where timing is of utmost importance is a major consideration in the planning of a test program: The priorities, the order of testing, and the impetus given to completion should be based on production requirements. There is little purpose in running flight tests for development of the last airplane on the line.

The testing of the airplane can be integrated into the production of the airplane: The embarrassing slips in schedules which result from hold orders that are too late or from struggles with underdeveloped items of equipment and procedures are largely unnecessary. In actuality, there have been many false premises established about the relationship between flight testing and manufacturing. It has been assumed for many years that the flight-test operation was subject to so many unknowns and technical problems that the complete testing of the airplane could not be scheduled, could not be planned, and that the production planning of the airplane had to be predicated upon incomplete flight testing. There is considerable evidence today that this assumption is not altogether true. There are hopeful indications that the prototype concept is giving way to a plan that will integrate flight testing with a slow build-up of airplanes that are complete and final in themselves. This does not mean "stretch out." It means a large number of test airplanes early enough to

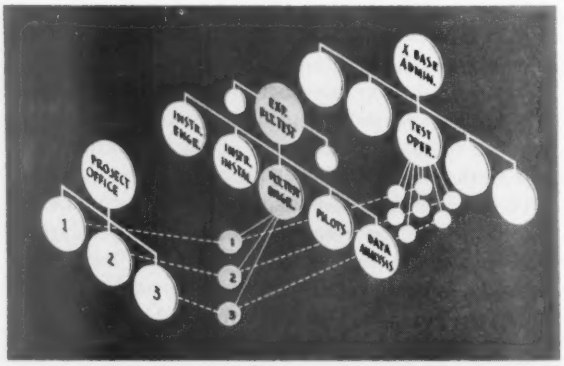

FIG. 4.

permit the adequate development of the airplane before high-rate production.

The organization shown in Fig. 4 should be looked upon as a development of the flight-test function, not as a change from a function or a change that relieves Flight Test of the responsibilities it has as a service function to Engineering.

This figure illustrates the functionalization of Flight Test and Engineering. It illustrates the provisions for the "close coordination with Engineering, Aerodynamics, and other design groups" which was one of the fundamental reasons for the establishment of the organization shown in Fig. 1. The coordination is maintained on a functional basis where the requirements of Engineering are funneled through the Project Office to the project flight-test engineer. He becomes the single channel, the clearing house. He is the one man in Flight Test who wears two hats. He is responsible to the project engineer for obtaining information by flight test which is required for design development. He is responsible to Flight Test for his methods and point of view. He serves the project engineer on the same functional basis as the project aerodynamicist or the project structures engineer or the project powerplant engineer does in any engineering organization that maintains a project-staff system.

Conclusions

To summarize the discussion: I have argued that the organization of Flight Test in the aircraft industry has been and is changing; that the first purpose of flight testing is inherently the objective evaluation of the complete airplane; that, to accomplish this purpose, Flight Test must have a clear pipe line to top management unimpeded by the subjectivity of Engineering, Sales, or Manufacturing; that, by the adaptation of a functionalized organization that is common to Engineering itself, it can maintain Engineering's requirement for technical and design information; that, by being independent of Engineering, it can regain its position as a service to Sales and Manufacturing.

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Operational Economics of **Scheduled Helicopter Transportation**

ROBERT L. CUMMINGS, JR.*
New York Airways, Inc.

IN MANY AVIATION GATHERINGS celebrating the fiftieth anniversary of flight, discussion of the future of the helicopter in commercial transportation has played an important part. Competent aeronautical engineers state that there is no inherent technical limit as to the size and capacity of helicopters. Vivid pictures have been painted showing giant rotor craft moving in scheduled service carrying passengers and all types of cargo. Subject to the development of satisfactory cost and revenue factors, there can be no doubt that this new dimension in transportation, the helicopter, is going to have an important impact on our way of life.

However, to those of us in the commercial operating end of this industry, the economic qualifications are basic. Future equipment must have drastically reduced cost characteristics and increased revenue-earning potentials. Costs must be reduced to a point where commercial traffic can be attracted and generated in volume. Put another way, it will take far more than the completion of a helicopter so engineered and mathematically correct that it cannot fail to fulfill all flight requirements. Perfection of engineering by itself is far short of enough. The economic factor can make or break an otherwise satisfactory design. In this connection, it has been repeatedly demonstrated that optimum equipment cannot be obtained without the highest degree of coordination between the manufacturers and operators, beginning with the earliest drawing-board planning.

That is why what New York Airways, Los Angeles Airways, and Helicopter Air Service are doing today is so vital. It is important not only to these companies, but, of far greater significance, it is also important to the forward development of the helicopter as a major auxiliary of the civil and national defenses and as the means to bring further progress to our social and economic way of life.

Moreover, it is obvious that the military operators can save the taxpayer substantial sums of money over the years by appropriate consideration of commercial requirements. In the final analysis, commercial and military operators have a common objective to a degree not generally true in the development of other types of aircraft.

It is a known fact that high costs are inherent in the infancy of a new service such as we perform. For present purposes, it may be helpful to discuss New York Airways' cost experience for the month of October, 1953, as a possible illustrative period. For this month, total costs amounted to $3.04 per revenue mile, of which $1.85 was direct and $1.19 indirect. Assuming an average available capacity of 1,000 lbs., the total cost per seat-mile would be slightly more than $0.60, the cost per available ton-mile being $6.08. This cost experience is not susceptible to comparisons with other forms of transportation. The helicopter is clearly not a truck or bus, neither is it a fixed-wing airplane. It has, of course, some attributes of each. It is a new dimension in transportation, meeting the demands of a changing community structure, where industry is moving into the suburbs and traffic congestion in city centers is becoming more and more intolerable.

This difference is recognized by various governmental agencies, both federal and local. Rules and regulations developed for other modes of transport have generally not been considered as setting precedents for the helicopter transport industry. This sensible approach must be continued if we are to obtain full advantage from this new vehicle.

Our operating characteristics can be highlighted by the cost experiences developed in the month of October, 1953. During this month, which we are using for illustration purposes, New York Airways operated a fleet of five S-55 helicopters and logged nearly 35,000 scheduled miles. The cost ran slightly over $100,000 for the month. As a practical matter, these costs may well be substantially higher than would be incurred in other communities. For example, in New York we have three major airports to staff and serve 24 hours a day. We have high rentals, landing fees, etc., which are beyond our control. Our performance factor has also proved to be disappointingly low because of weather. About 16 per cent of our scheduled flights during this past year were canceled for this reason and only 1 per cent because of mechanical problems. An operation with small equipment limited to daylight would incur much lower costs but, at the same time, would not serve the purposes for which New York Airways was certificated. Specifically, smaller equipment would not permit the development of cargo and passenger sources of revenue and would not be able to fly at night because of pay-load restrictions.

There are a number of factors inflating our cost structure and over which we can exert little influence at present. For instance, by the very nature of our

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operations, an unusual amount of maintenance is required; for every hour of flying time, 6 man-hours of maintenance are necessary. Utilization over the last 12 months has averaged less than 4 hours daily, which obviously makes for high depreciation charges. Further, our aircraft insurance premiums are premised on an annual basis without regard for utilization. As we are allowed to *increase* our daily utilization factor, so will we be able to *decrease* our unit depreciation and insurance costs. The nature of our operations also plagues us with an abnormally high degree of nonrevenue miles to maintain our existing schedule pattern. For noise and safety reasons, our flight path between Idlewild and Newark *alone* takes us 29 miles, whereas the direct line measures less than 21 miles.

But, as a result of experience and exposure to problems in need of remedial action, the operator and manufacturer will be in a position to make such modifications that costs will ultimately be reduced and the quality and scope of our service greatly improved. It is not unrealistic to expect that, now that they have developed a successful operating machine, the helicopter engineers will devote considerable energy to refining this vehicle so that its characteristics will become increasingly more efficient and economical. Again, this has been the evolution in the development of the fixed-wing airplane. It will be true with the helicopter.

Nevertheless, even at present, in evaluating helicopter services, the user is concerned with the time saved. When the number of miles to be traveled is extremely small, the cost per mile has lessening importance. Remember, the versatility and utility of the helicopter as a transportation instrument are centered primarily in the ability to move passengers and cargo quickly and safely over congested areas and geographical obstacles with actual distances being relatively limited and, in any case, of minor importance.

Operations such as New York Airways, Los Angeles Airways, and Helicopter Air Service are conducting and not only working the bugs out of today's machines but they are also greatly accelerating the evolution of more effective equipment through their continuing experiments and accumulation of experience. Day in and day out, operations are uncovering and solving problems that would not otherwise be encountered. This is true equally in both the technical and business aspects of this new industry. As vibration and noise problems have been encountered, measures have been undertaken which promise a successful solution. Similarly, navigation and traffic control difficulties are being solved. Maintenance procedures and operation techniques are being constantly improved. Similarly, specially adapted procedures are evolving for passenger handling and loading and unloading freight—all with a minimum of paper work and personnel.

We are proving once again that there are no short cuts, no cheap or inexpensive ways to develop a new means of transportation. There is no substitute for actual operations under commercial conditions where problems arise and are solved by management specifically charged with the responsibility. In this process the three operators certificated in the United States are making essential contributions to the future of the helicopter transportation industry. They are accelerating the day when improved equipment may serve all the leading communities throughout the country on a sound economic basis.

No discussion of the value of the presently functioning helicopter transportation industry can be rationally concluded without mention of the role it now occupies in the civil defense organization. Clearly this has future implications of major proportions. Soon after the inauguration of our service here in New York, all our operating personnel and fleet were enrolled as an adjunct of the metropolitan civil defense program with specific tasks and responsibilities assigned in case of any emergency requiring helicopter transportation. It is obvious that, as experience accumulates and equipment improves, our ability to perform will likewise rapidly develop. Here again, it is recognized that this new vehicle can perform a combination of vital services of which no other vehicle yet conceived is capable. It can provide the only feasible transportation into and across radioactive areas. It can lay communication lines where these are required. It can transport the injured and solve traffic problems. The possibility of emergencies of the proportions described above must be considered remote. Even so, it is plain that a fleet of helicopters with trained personnel should be available for the contingency in the vicinity of all highly congested areas. It is equally plain that neither the military nor the civil defense organizations can afford to have stand-by equipment on a full-time basis. Beyond any doubt, today's commercial helicopter transportation operators are demonstrating their ability to assume this important responsibility.

Two years ago, when the Civil Aeronautics Board certificated New York Airways, it recognized this important function among other broad objectives to be served by our service. It asserted in its opinion at that time, among other things: "Substantial contributions to the national defense, both civil and military, as well as benefits to the commercial and postal service, should be experienced well before the time larger and more efficient aircraft become available. . . ."

We have referred from time to time to the dependence of present-day helicopter operators on Government support in the form of subsidy. It is apparent that such support is essential at this time to this fledging industry. For fiscal 1954, the Civil Aeronautics Board has projected some $2,600,000 as the aggregate mail pay for New York Airways, Los Angeles Airways, and Helicopter Air Service. Of this amount, about $2,300,000 are labeled as outright subsidy and the remainder is payable to the carriers for the transportation of United States mail at the arbitrary rate of $2.58 a ton-mile. Total mail pay for New York Airways alone is

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We have referred from time to time to the dependence of present-day helicopter operators on Government support in the form of subsidy. It is apparent that such support is essential at this time to this fledging industry. For fiscal 1954, the Civil Aeronautics Board has projected some $2,600,000 as the aggregate mail pay for New York Airways, Los Angeles Airways, and Helicopter Air Service. Of this amount, about $2,300,000 are labeled as outright subsidy and the remainder is payable to the carriers for the transportation of United States mail at the arbitrary rate of $2.58 a ton-mile. Total mail pay for New York Airways alone is

estimated at $1,250,000. This figure will doubtless be adjusted as our operation stabilizes and more facts governing the level of expenses and commercial revenue possible become known.

An interesting parallel is found in the basis of the formation of the Air Transport Command and its substantial contribution to the military effort during World War II. It was able to perform the Herculean tasks assigned to it on such short notice at the outset of hostilities because commercial transportation companies had been developed through extremely substantial Government support to a point where their organizations and equipment were immediately available on need to become integral parts of our national defense. It is a known fact that if it had not been for this Government support, which was many times the amount now required by the helicopter transportation industry, the development of the fixed-wing as a commercial transportation vehicle would have been so retarded that the very existence of the United States could have been in jeopardy when the war emergency suddenly arose.

It is my conviction that we should never think about subsidy as a permanent crutch for any industry. An industry, if it justifies any subsidy in the first place, must be able to foresee rationally its own independence. In the case of the helicopter transportation industry, given the cooperation of the manufacturer and the military and the interim support of the Government, it is not difficult to foresee a day when it will be able to balance its books and show a profit on a commercial self-sustaining basis.

The helicopter is a *creative* vehicle. It will uncover entirely new markets and generate new business volume not now available to long-established transportation media. The helicopter with its unique characteristics is the new transportation dimension that can cultivate and develop these new markets.

Not so long ago, when the airplane first appeared in transatlantic travel, there were those who asserted that volume in this area was extremely limited. This was erroneously based on the fact that only a handful of airplanes could handle the passenger volume then moving by steamships. While from a static point of view this was correct, cold realities proved how wrong past statistical data can be without a little forward imagination. It is, of course, well known what has since happened. The airplane with its speed, flexibility, and low cost has gone on to create entirely new markets and boomed passenger transatlantic volume to progressively new peaks. On the other hand, it should be noted that, during this same period, steamship traffic has also increased.

In closing, it is evident that we and our friends at Los Angeles Airways and Helicopter Air Service are making substantial contributions in the national interest. None of these things would have been possible without the financial support of the many investors who have assumed the risk and furnished the essential equity capital without hope of immediate return. With a fuller understanding of our accomplishments and of the far greater potentialities yet to be realized, the relatively limited Government support we require will be recognized as of a self-liquidating nature of benefit to the entire country.

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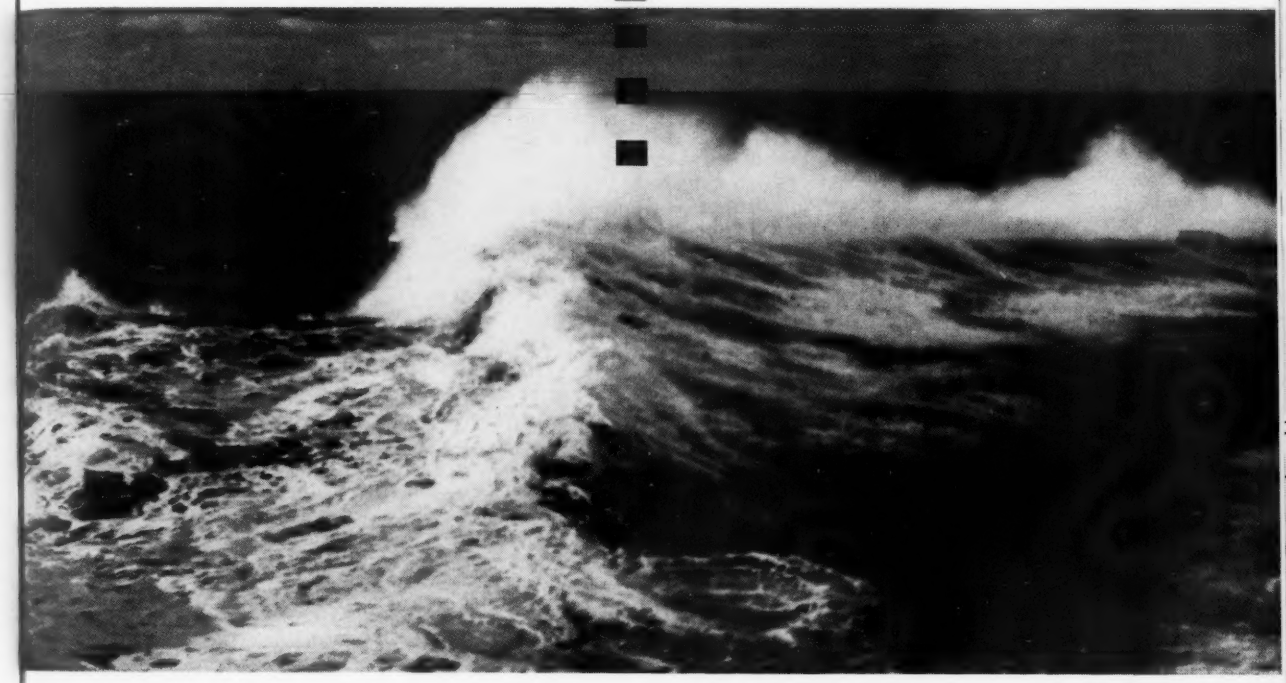

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IAS News

(*Continued from page 39*)

Edmund G. Cook, Jr. (M), Sales Engineer, The Weatherhead Company. Formerly, Pilot, Weatherhead.

Corwin D. Denney (M), General Manager, American Helicopter Division, Fairchild Engine and Airplane Corporation. Formerly, President, American Helicopter Company, Inc.

William N. Engel (M), Chief Engineer, Culver City (Calif.) Plant, Midwest Division, H & B American Machine Company. Formerly, Chief Engineer, Indianapolis (Ind.) Plant, Midwest Division, H & B American Machine Company.

George A. Estabrook (M), Readyness and Reliability Staff Engineer, Missile Systems Division, Lockheed Aircraft Corporation. Formerly, Design Specialist, California Division, Lockheed.

Edward F. Flint (M), Special Products Division, Sales Department, Kodak Office, Eastman Kodak Company, Rochester, N.Y. Formerly, Engineering Department, Hawk-Eye Works, Eastman Kodak Company.

William L. Gore (M), Director of Sales, Azusa and Sacramento divisions, Aerojet-General Corporation. Formerly, Director of Field Service, Aerojet-General.

Willis M. Hawkins (M), Chief Engineer, Missile Systems Division, Lockheed Aircraft Corporation. Formerly, Chief Preliminary Design Engineer, California Division, Lockheed.

R. Richard Heppe (M), Aerodynamics Department Manager, California Div., Lockheed Aircraft Corp. Formerly, Aerodynamics Group Engineer, Lockheed.

Jim Hong (M), Aerodynamics Division Manager, California Division, Lockheed Aircraft Corporation. Formerly, Aerodynamics Department Manager, Lockheed.

Ephraim M. Howard (AF), Engineer, Test Projects Control Group, Experimental Test Section, Allison Division, General Motors Corporation. Formerly, Manager, Ram Jet Branch, Engine Test Facility, Arnold Engineering Development Center.

Reinout P. Kroon (M), Director of Research, Aviation Gas Turbine Division, Westinghouse Electric Corporation. Formerly, Manager of Engineering, Aviation Gas Turbine Division, Westinghouse.

Joseph W. Lawsing (TM), Product Engineer, Jet Fuel Controls, Hamilton Standard Division, United Aircraft Corporation. Formerly, Senior Engineer, Melpar Inc., Division, Westinghouse Air Brake Company.

Hal Paiss (M), Operations Analyst, Weapon Systems Analysis Group, Northrop Aircraft, Inc. Formerly, Executive Vice-President and General Manager, Intercontinental Airways, Inc.

Charles R. Plum (M), Project Manager, Aircraft Accessory Turbine Department, General Electric Company. Formerly, Manager, Product Service, Jet Engine Department, G-E.

Howard E. Roberts (AF), Director of Engineering, American Helicopter Division, Fairchild Engine and Airplane Corporation. Formerly, Vice-President—Engineering, American Helicopter Company, Inc.

Arthur L. Ross (M), Analysis Design Section, ANP Project, General Electric Company, Cincinnati, Ohio. Formerly, Research Assistant, Department of Aeronautical Engineering, New York University.

Will C. Sievert (M), Hearing Officer, Civil Aeronautics Board, Washington, D.C. Formerly, Air Safety Investigator, Bureau of Safety Investigation, CAB, Chicago.

H. B. Slate (M), Aviation Engineering, Aircraft Accessory Turbine Department, General Electric Company, West Lynn, Mass. Formerly, Applications Engineer, Aviation Division, G-E.

John A. Smith (TM), Research Engineer, Allied Research Associates, Inc. Formerly, Structures Engineer, Fort Worth Division, Consolidated Vultee Aircraft Corporation.

Nicholas M. Stefano (M), Chief Engineer, American Helicopter Division, Fairchild Engine and Airplane Corporation. Formerly, with Hughes Aircraft Company.

Cyril C. Thompson (AM), Special Consultant, CAA. Formerly, Executive Secretary, Airport Operators Council.

Ensign James Ray Throop, USN (TM), Student Naval Aviator, BTU-1C, NAAS Corry Field, Pensacola, Fla. Formerly, Line Officer, U.S.S. "Wilkinson."

Stanley Timoshek (TM), Sales Trainee, The Dow Chemical Company. Formerly, Structures Engineer, Canadair Limited.

Curtis L. Walker (M), Secretary, Subcommittee for Power Plant Controls, Headquarters Staff, NACA, Washington, D.C. Formerly, Aeronautical Research Scientist, Engine Research Division, Lewis Flight Propulsion Laboratory, NACA.

Carl Robert Wetterau (M), Manager, Test and Handling Equipment Division, Pacific Airmotive Corporation. Formerly, Assistant Chief Engineer, Greer Hydraulics, Inc.

Bertram C. Wollner (M), Aircraft Structures Engineer—Senior, Georgia Division, Lockheed Aircraft Corporation. Formerly, Structural Air Loads Engineer, Bureau of Aeronautics, Department of the Navy, Washington, D.C.

J. F. Schirtzinger, MIAS, has been appointed President and General Manager of Consolidated Tool & Products Company. For the past 5 years, Mr. Schirtzinger was Assistant Chief Engineer, San Diego Division, Consolidated Vultee Aircraft Corp.

Corporate Member News

•**Aerojet-General Corporation.** . .A licensing agreement has been completed by Aerojet and Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, of France, for the manufacture by Aerojet of an SNECMA device that reverses the thrust of turbojet engines. The French company claims that the unit, which uses annular baffles to achieve the reversing action, will completely stop an aircraft in less than half the distance normally required without the necessity of throttling the engines.

•**Aeroquip Corporation.** . .Aero-Coupling Corporation, Aeroquip's West Coast subsidiary, has enlarged its Burbank, Calif., plant with a new 5,400-sq.ft. plant.

•**Air Associates, Inc.** . . .The recently published Catalog 21d, the fourth in the company's 21 series, covers aviation electrical and radio equipment, including descriptive and technical data. The contents of this catalog have been sectionalized according to the respective aircraft applications. The prices of the equipment referred to in Catalog 21d are contained in a separate price book.

•**Airborne Accessories Corporation.** . .A magnetic amplifier, engineered primarily for Airborne actuated control systems, is said to afford a simple and reliable means of amplifying feeble electrical signals generated by the dynamic air-pressure instrument of the servo system into electrical currents strong enough to operate equipment directly or to energize relays for the same purpose. Complete information on Airborne magnetic amplifiers and on Airborne control systems is available on request from the corporation's Hillside, N.J., office.

•**Airborne Instruments Laboratory, Inc.** . . William H. Dobbins has been elected Treasurer of the corporation.

•**AiResearch Manufacturing Company.** . . A 64-page catalog, recently published by AiResearch, outlines the applications and specifications of 20 basic types of company-produced linear and rotary actuators, power units, jacks, gear boxes, and ammunition boosters. (The company manufactures some 300 different models in these fields.) This new publication is illustrated with photographs, charts, and engineering drawings. Copies may be had from the company's Los Angeles office.

•**American Phenolic Corporation.** . .The company states that the new 165 Series of

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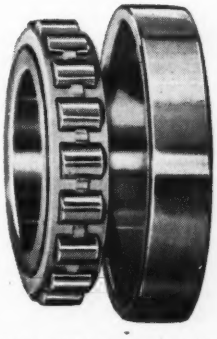

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

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ROLLER BEARINGS

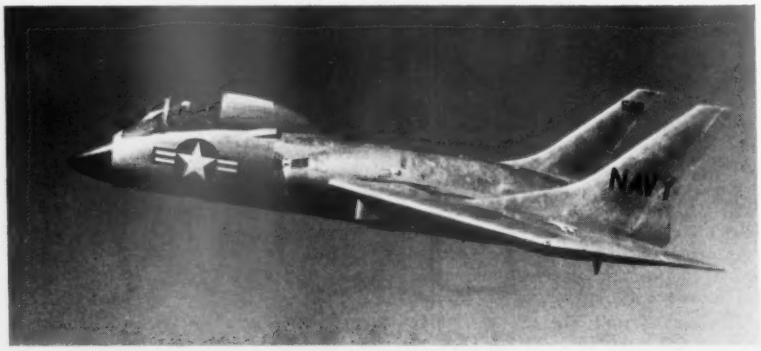
The Cessna Aircraft Company is currently proceeding with the aircraft production engineering and the air-frame tooling design necessary to sustain maximum production of the T-37A, an artist's drawing of which is shown here. The T-37A is a side-by-side jet-propelled trainer that is scheduled to be produced for the USAF Training Command.

Miniature AN Connectors is markedly reduced in weight. The new connectors are expected to be used extensively in modern aircraft, rockets, and missiles. They are available in two sizes and in six configurations—with 5, 9, 11, 12, 14 of 24 gold-plated contacts.

• **Bell Aircraft Corporation. . .**An electronic remote control system that makes it possible to land a guided missile undamaged after a flight test has been designed and developed by Bell. This system has been used extensively in flight testing the Regulus, a surface-to-surface guided missile developed by Chance Vought Aircraft, Inc., for the USN BuAer for launching from submarines, surface ships, and shore bases. This system, also known as proportional control, is said to have reduced the number of missiles needed in the Regulus test program by about 75 per cent and to have cut to at least one-tenth the cost of a comparable operation were the missile lost on each test. One Regulus missile was tested as many as 15 times in 1953 and was landed by the Bell system without damage. . . .Servomechanism engineers of the company's Niagara Frontier Division have developed an automatic pilot for the Bell HSL-1 helicopter. It is said to be the first auto-pilot to fly an antisubmarine helicopter during operation of its air-borne sonar equipment and to stabilize it successfully. One of the features of this auto-pilot is that the pilot can insert commands into the system directly through the cyclic control stick and rudder pedals. The auto-pilot has become standard equipment for the Navy's HSL-1, now being produced at Bell's helicopter plant near Fort Worth, Tex.

• **Bendix Aviation Corporation. . .**A new GCA system has been developed at the Bendix Radio Division's Baltimore plant under a CAA contract, according to a recent company announcement. This new airport radar is said to be capable of landing any aircraft equipped for normal instrument flight "regardless of visibility" and to permit landings and take-offs at the rate of one a minute during periods of minimum weather conditions. This GCA system has two separate units: the airport surveillance radar (ASR-3) for air traffic control from 20 to 50 miles of the airport and the precision approach radar (PAR-2) for monitoring aircraft on final landing approach. A Bendix official stated that the new radar equipment includes these major developments: (1) operator-controlled moving-target indication, enabling the airport radar operator to cancel out instantly fixed objects (mountains and ground obstructions) appearing on his radarscope; (2) operator-controlled video mapping, which electronically reproduces on the face of the radarscope a map of the area covered by the radar surveillance and shows selected danger spots (e.g., tall buildings and power lines) in relation to aircraft in the area; (3) automatic direction finder, that provides instant radar aid to identification of an aircraft on the radarscope as soon as voice-radio contact has been made; and (4) circular polarization, that uses a Bendix-developed quick-change antenna to permit transmission of a "rotating field" radar beam for greater penetration of storms. . . .The Pacific Division has announced two new telemeter packages incorporating plug-in subcarrier oscillators. These units, when used with power supply and RF transmitter, provide a "compact rugged" FM/FM system for telemetering many functions. One of the new packages is designated as Model TATP-3 and operates in any four of the RDB bands below 22 kc. The other one, Model TATP-4, operates in any of the bands from 22 kc. up. Standard power supplies are also available from the company for operating up to three packages in combination with the Bendix Pacific 2-watt crystal-controlled RF transmitter. Technical data sheets on these two telemetering models may be had by writing to the division's North Hollywood, Calif., offices. . . .Type TG-19 VHF Fixed Station Transmitter has been announced by Bendix Radio Division. This is a crystal-controlled 50-watt ground-station transmitter for ground-to-air and point-to-point services including airport installations. It is designed to operate in the frequency range from 108.0 to 135.9 megacycles providing amplitude modulated cw signals. Facilities are provided for adding a second crystal to permit dual-channel operation on output frequencies that differ by 800 kc. or less. The TG-19 VHF Fixed Station Transmitter is designed as a companion unit for the Bendix Type RG-9A VHF Fixed Station Receiver, which covers approximately the same range. . . .New wheel test equipment that allows aircraft wheels to be static tested for radial load and side load has been designed and built in the Engineering Laboratories of Bendix Products Division. The apparatus was designed to permit axle deflections to be introduced into the testing or the axle to maintain a horizontal position. Wheels, it is said, can be tested by this apparatus with combined loads of any degree, varying from 100 per cent vertical load to a combined side load equalling the vertical load. . . .The Red Bank Division has announced a new beam power amplifier, RETMA 6094, designed to replace the 6AQ5/6005 and other such tube types. The 6094 is for use in equipment in which high-ambient temperatures and high levels of vibration,

The F7U-3 Cutlass is now being quantity-produced for the U.S. Navy by Chance Vought Aircraft, Inc. Powered by two of Westinghouse Electric Corporation's J-46 jet engines, this swept-wing fighter is capable of a top straight-and-level speed in excess of 650 m.p.h., has a rate of climb of more than 13,000 ft. per min., and has a combat ceiling that exceeds 45,000 ft. The F7U-3 is equipped with folding wings and arresting gear for carrier operations. Regular armament of this carrier-based aircraft consists of 20-mm. cannon and a belly pack housing air-to-air rockets; the Cutlass, however, is designed also to carry bombs and other bomb-type weapons. The Navy has ordered an attack version of the F7U-3, the A2U-1.



New DOUGLAS DC-7 Uses New VICKERS® Variable Displacement Hydraulic Pumps

Cabin supercharger drives on the new Douglas DC-7 use the largest known variable delivery aircraft hydraulic pump . . . the new Vickers PV-3918. Like the DC-7, the PV-3918 is an outgrowth of previous successful designs.

This pump is a development from similar but smaller pumps used in the DC-6, DC-6A and DC-6B. The basic application was so successful it was adopted for the new DC-7. The new pump provides a 147% increase in flow capacity with only a 50% increase in weight. A special feature of the PV-3918 is an overspeed control which automatically limits the maximum pump delivery and accordingly provides another safety check on compressor impeller speed.

For further information about the numerous advantages of Vickers Variable Displacement Piston Type Pumps, ask for Bulletin A-5203.

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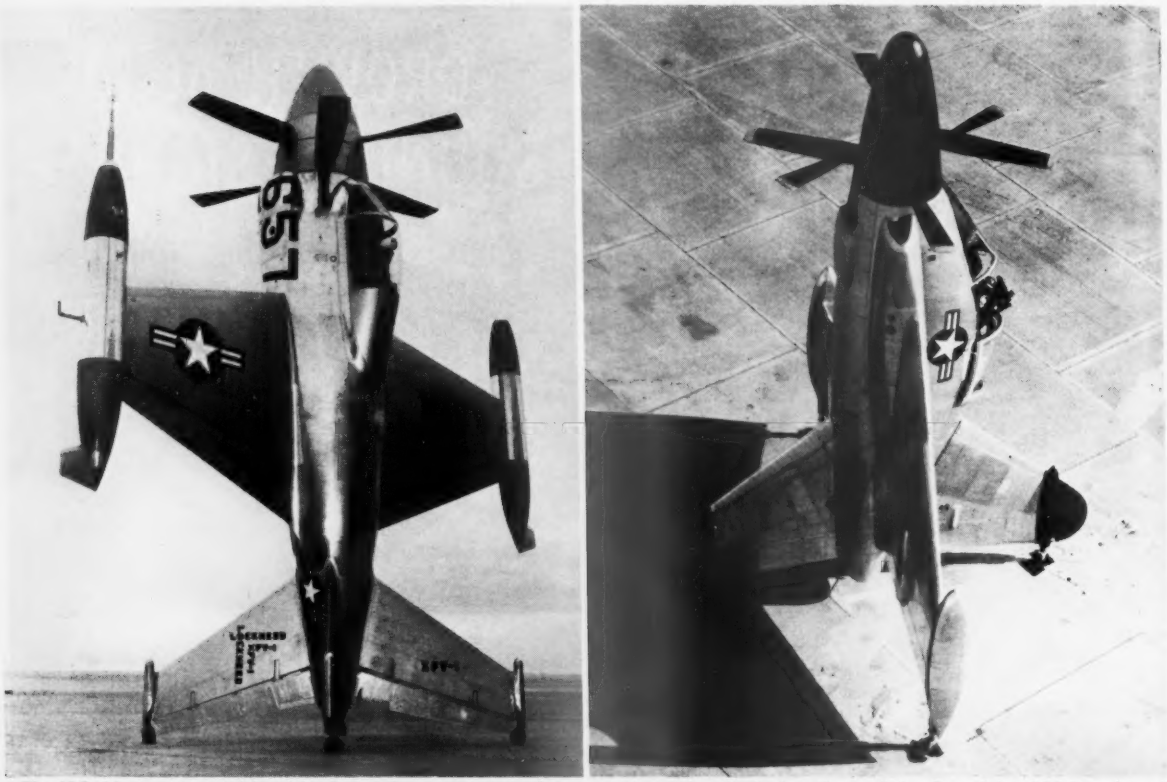

The U.S. Navy announced last March that the construction of two experimental vertical-take-off aircraft by Consolidated Vultee Aircraft Corporation and Lockheed Aircraft Corporation had proceeded to the point where engine and preflight tests are in progress. Lockheed's XFV-1 straight-wing fighter is shown at the left; Convair's XFY-1 delta-wing fighter is at the right. Both ships have been under construction for nearly 3 years and are designed to take off and land vertically and to fly horizontally at fighter speeds. These VTO aircraft are equipped with specially designed contrarotating propellers powered by T-40 turboprop engines, manufactured by Allison Division of General Motors Corporation. A specially designed rotatable seat arrangement in each aircraft enables the pilot to assume the suitable positions for the vertical take-offs and landings and for level flight. Details of design and performance and the ships' dimensions have not been announced. J. F. (Skeets) Coleman, of Convair, and H. R. (Fish) Salmon, of Lockheed, are the test pilots for the XFY-1 and the XFV-1, respectively.

shock, and other accelerations are encountered. A hard glass (Nonex) bulb and stem with tungsten pins are used in the tube. It is said that this, along with careful exhaust to a very low vacuum, permits operation of the 6094 at bulb temperatures up to 300°C. Ceramic spacers are used for element separation. The tubes have a cathode-type structure with extruded ceramic heater insulator and a coil-type heater. The 6094, which has a 9-pin miniature button base and can reportedly operate at altitudes up to 80,000 ft. is especially designed for aircraft, industrial, military, and other applications where severe environmental conditions are encountered. A 4-page catalog on the 6094 is available from the Red Bank Division. . . .A study agreement aimed at the practical application of atomic power and its by-products has been worked out between Bendix Aviation and the U.S. Atomic Energy Commission. Bendix Aviation's study deals with the future of atomic power and by-products, anticipating the development of new reactor designs and the discovery of new uses for radioactive isotopes or fission products. (The corporation has made four reports to the AEC on small reactor power plants and one report on the commercial utilization of radioactive isotopes. It is also engaged with Oak Ridge National Laboratory in some reactor studies.) The new Bendix-AEC agreement runs for 1 year, with all costs being borne by Bendix. At the end of the contract period, a report summarizing the findings and recommendations will be submitted to the AEC for appropriate action.

• **Boeing Airplane Company.** . .The B-47 Stratojets now being delivered to the USAF Strategic Air Command, known as the B-47E, are provided with an increase in available take-off power through a new external rocket arrangement and a water-injection system in the bomber's six jet engines. The B-47E is equipped with a new collar-type rocket rack that is mounted beneath the fuselage and has positions for 33 ATO units of 1,000 lbs. of thrust each. This new rocket rack increases by 15 the number of ATO units carried. It is possible for both systems, the water injection and the ATO units, to be used simultaneously. However, Boeing engineers have pointed out that this would be done only under extreme conditions. The B-47E has a maximum gross weight of 200,000 lbs., 15,000 more than earlier models. . . .The first production airplane of the B-52 Stratofortress series was rolled out of the Boeing Seattle, Wash., plant on March 18. This bomber has a wing span of 185 ft., a length of 156 ft., and a 48-ft. high vertical tail. It is powered by eight Pratt & Whitney J-57 turbojet engines and has a gross take-off weight of more than 350,000 lbs.

• **Consolidated Vultee Aircraft Corporation.** . .The Convair C-131A Samaritan, the military version of the Convair 240 transport, has been added to the domestic air evacuation fleet of the Military Air Transport Service. In varying combinations of seating-litter arrangements, this 235-m.p.h. plane can accommodate up to 37 seats or 27 litters and 7 seats. All seats face rearward. Normally, one flight nurse and two medical attendants accompany Armed Forces patients on regular runs. The ship is air conditioned as well as pressurized.

• **Cornell Aeronautical Laboratory, Inc.** . . . A small transonic-supersonic wind tunnel, now under construction, is scheduled to go into operation early this summer. A vertical-return closed wind tunnel of variable density, it will be capable of speeds of about Mach 3 and will include operation in the Mach 0.8 to 1.2 transonic speed range. It will require 2,000 hp. for operation and will have a 1-sq.ft. testing area. This tunnel is being built as part of two programs for the Air Force by the Laboratory's Aerodynamic Research Department. One study calls for determining how transonic testing in wind tunnels compares with true flight conditions and to correcting for differences. The other inves-

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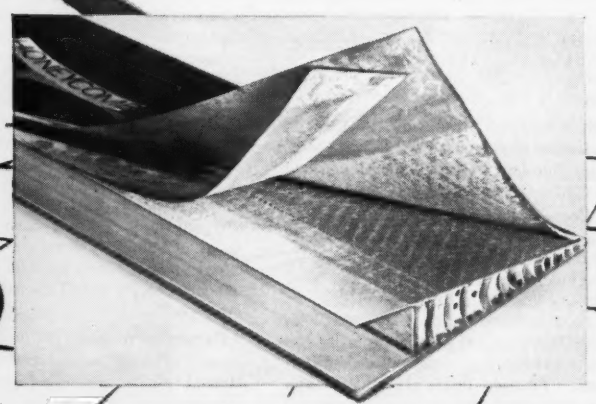

Section through a trailing edge, showing honeycomb sandwich wing construction. Laminations such as these may be assembled immediately after application of solvent-free Epon resin adhesives.

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The F9F-8, the newest version of the Cougar, is now in production at Grumman Aircraft Engineering Corporation. Modifications in the leading and trailing edges of the F9F-8's wing and the lengthening of the fuselage are said to have improved the ship's performance. Design changes enable the F9F-8 to carry an increase of 140 gal. over the earlier Cougars, thus giving it a greater range. The F9F-8 Cougar is powered with a Pratt & Whitney J-48 turbojet engine.

tigation involves designing a scoop for supersonic wind tunnels for removing effectively the polluted and explosive exhaust of jet engines under test. . . .A project to determine the desirable handling characteristics of military aircraft is now being conducted at the Laboratory under USAF sponsorship. As a part of this study, the Laboratory is developing equipment to provide an F-94 Starfire with stability and control characteristics that can be varied in flight. This equipment in effect changes the aircraft's design characteristics and hence its handling behavior in flight. This is achieved by a maze of highly specialized automatic, mechanical, and electronic equipment controlled by a set of knobs in the cockpit. A safety pilot accompanies the regular pilot on each flight in order to disengage the aircraft's experimental stability and control system in case of its failure. The disengaging of this system returns the plane to normal flight control.

• **Curtiss-Wright Corporation. . .**A flight simulator for the Boeing B-52 Stratofortress jet bomber is now being developed under contract.

• **Edo Corporation. . .**A new seaplane float with a 2,870-lb. displacement has been placed on the market. It was designed by Edo engineers for use on aircraft that have a landplane gross weight in the vicinity of 2,500 to 2,700 lbs., e.g., a Cessna 180. This 2,870-lb. model, which replaces the smaller 2,424-lb. float, retains Edo's fluted bottoms. The new floats are said to have greatly improved rudder control and to have a new molded-rubber bow bumper. The new 2,870's show no increase in drag over the 2,425's.

• **Fairchild Engine and Airplane Corporation. . .**The assets of American Helicopter Company were acquired by Fairchild on last March 18. Two weeks later, on April 1, the operations of American Helicopter Company were continued as the American Helicopter Division of Fairchild. This new division has facilities at Manhattan Beach, Calif., Costa Mesa, Calif., and Mesa, Ariz. Corwin D. Denney, MIAS, formerly President of American Helicopter Company, became General Manager of the American Helicopter Division of Fairchild.

• **General Electric Company. . .**A new fire control system has been developed for supersonic aircraft, according to a recent announcement by G-E's Aeronautic and Ordnance Systems Division. This system is said to be capable of locking on the invading aircraft, automatically guiding the plane to the correct firing point, and then firing the guns. Upon the mission's being accomplished, the system automatically guides the plane out of danger. The pilot turns the control of his plane over to this automatic system, after the plane is airborne and the enemy intruder's relative position, course, and speed have been determined by the ship's radar. . . .According to a recent company release, an automatic electrical system for high-performance aircraft has been developed which eliminates a minimum of at least ten pilot functions and requires no manual switching. Major components of the automatic a-c system are high-efficiency alternators, static voltage regulators, and generator control and protective panels. It is said that this new high-efficiency generator is capable of withstanding temperatures of 176°F. . . . A new G-E plant that will be used for the manufacture of electronic controls for industrial and aviation uses is now under construction at Waynesboro, Va. Located on a 70-acre site, this new factory is expected to be in full operation some time next year.

• **General Precision Equipment Corporation. . .**It was announced on March 22 that Link Aviation, Inc., and General Precision have entered into an agreement by which Link Aviation becomes an affiliate of General Precision. This agreement became effective April 30, when General Precision acquired 95 per cent of Link's outstanding stock. The operation of Link continues under the same management, with Edwin A. Link, MIAS, Board Chairman, Allan Williford, President, and other principal officers continuing in their respective capacities.

• **The Goodyear Tire and Rubber Company. . .**AiResearch Aviation Service Company recently completed the installation of Goodyear-manufactured nylon fuel cells into a Goodyear-owned Lockheed Lodestar. Complete CAA approval has been given. This is the first time that this type of fuel cell has been installed in a Lodestar. These cells increase the fuel capacity of the Lodestar from 638 to 820 usable gals., thus extending its range by some 500 miles. There is no appreciable weight increase, inasmuch as the largest of these nylon bags weighs only 6.5 lbs. Goodyear nylon fuel cells are built into all Grumman SA-16's and into Boeing Stratocruisers and KB-29's and are included in Fairchild C-119's.

• **Industrial Sound Control, Inc. . .**A 3.5-lb. muffler, 5 in. sq. by 10 in. long, has been developed to whip the whine of jet-cockpit air-conditioning systems. Constructed of steel-lined aluminum, it combines "effective noise reduction with minimum pressure drop" and will operate at temperatures of 500°F. and above. Tests of this muffler indicate that it provides a 50-db. high-band attenuation and an overall noise reduction up to 23 db.

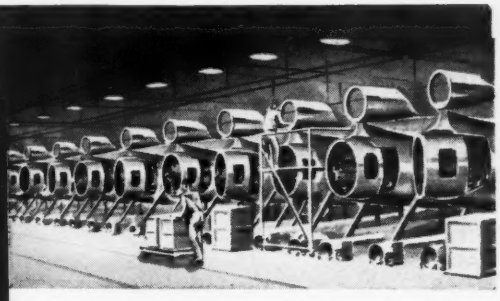
• **Kollsman Instrument Corporation. . .**An instrument, designed to measure jet-engine performance by considering the ratio of engine-exhaust-tailpipe total pressure to engine-inlet total pressure, is now on the market. The Turbojet Pressure Ratio Indicator is available in two systems, either a direct reading unit or a remote indicating system. The Turbojet Pressure Ratio Systems have Type Numbers KS 42-01 and KS 42-02.

• **Lear, Incorporated. . .**The newly developed remote-reference Pictorial Vertical Gyro Attitude Indicator (Model 978-K) was designed to simplify the problems of instrument flight in high-performance jet aircraft. The new instrument, which receives attitude reference signals from a Lear Type K-4 control mounted remotedly in the aircraft, has a universally mounted spherical background painted to simulate sky, horizon, and earth. A stationary miniature reference airplane is in the foreground. Airplane attitudes up to 85° of climb or dive are indicated by horizontal markings of 5° separation on the face of the sphere, while the exact bank angles are shown on a semicircular bank scale located on the upper half of the instrument. The instrument is servo driven. . . .The Santa Monica, Calif., facility of the Lear Aircraft Service Division has been designated a CAA Certified Repair Station. It now holds the Air Agency Certificate, Airframe Rating, Classes 1, 2, 3, and 4.

• **Lockheed Aircraft Corporation. . .**The T-33, the two-place training version of the F-80, has been converted into a one-place photo-reconnaissance ship, known as the RT-33. The nose of the RT-33 has been changed from the T-33's needle-sharp one to a bulbous one in which four mapping and charting cameras are mounted. (This same space in the T-33 contains machine guns and ammunition holders.) These four cameras can take photographs straight down, obliquely right or left, or directly forward. A tape recorder is part of the RT-33's equipment and permits the pilot to describe whatever he sees. Thus he can simultaneously photograph and orally pinpoint the target, his position and altitude, and distinguishing terrain features. The RT-33 is now in production.

• **Minneapolis-Honeywell Regulator Company. . .**The development and mass production of "the most sensitive air-borne

deadly trigger finger..



..built by CROSLEY

Concealed in the B-47 bomber is a Crosley-built Fire Control System to put the finger on enemy planes fast. Radar tracks them down and the mechanical brain computes all factors, lays the guns right on target.

It's a complex system but hardly a challenge to the Crosley background in radar and fire control, either airborne, shipboard, ground, mobile or fixed radar, and sonar.

Crosley defense production not only spans the whole field of electronics but has an equally wide spread in the mechanical and electro-mechanical fields, from components to complete weapons systems.

[redacted] Crosley has lived up to schedules on government development and production contracts—proof that Crosley does the job RIGHT and delivers ON TIME. Proof too, that the close Crosley coordination of research, development and manufacturing skills pays off fast in production of equipments and systems to meet rigid military specifications.

● "Right and On Time," an illustrated booklet describing Crosley facilities for military production, is available to Procurement Agencies and other defense contractors. Be sure to write for your copy today.

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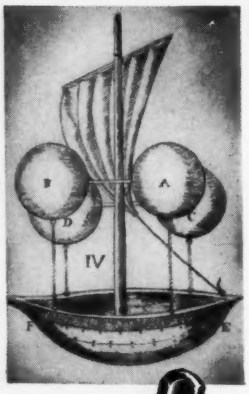
DESIGN FOR FLYING BOAT

WITH VACUUM-GLOBE LIFT

by 1670

Francesco Lana



Quite a change in aviation concepts since 1670! And with changes came a need for greater drafting precision. In the 300 years since Staedtler pencils were first produced, J. S. Staedtler of Nurnberg, Germany, has made constant improvements in pencil design and manufacture to keep pace with this need. Today, the Mars-Lumograph is America's finest imported drawing pencil; in the clutch pencil field the combination of the new 1001 Mars Technico push-button lead holder and 1904 Mars-Lumograph imported drawing leads insures your having the very best.

The 2886 Mars-Lumograph drawing pencil gives you precise thickness and the blackness of line needed for crisper, cleaner prints. Perfectly graded in 19 degrees; EXEXB to 9H. $1.50 per dozen—less in quantity.

The 1001 Technico Mars-Lumograph push-button lead holder costs no more than ordinary holders, has a noiseless, smooth-working, low-friction clutch mechanism, lightweight wood construction with perfect balance and, built into the push-button cap, a unique lead sharpener. $1.50 each—less in quantity.

1904 Mars-Lumograph Imported Drawing Leads are so opaque that inking-in is not necessary. Leads are ribbed for firm clutch grip and each has a removable cap which prevents sliding from holder. Available in 18 degrees; EXB to 9H. $1.20 per dozen—less in quantity.

J.S. STAEDTLER, INC.

31 DICAROLIS COURT

HACKENSACK, NEW JERSEY

instrument ever built" was recently disclosed by Minneapolis-Honeywell. This instrument, cylinder-shaped and weighing less than 3 lbs., was developed for use by the USAF in automatic flight control systems for supersonic and pilotless aircraft, including advanced guidance, bombing, and gun fire control systems. Its measurements are electrically transmitted to servomotors, or other components, to adjust automatically the operation of such systems. This gyroscope, jewel-mounted in a special oily fluid to reduce friction, can measure angles smaller than 1/36,000 of one degree of arc. The company's Aeronautical Division began development work on this gyroscope 5 years ago, following initial design work done at Massachusetts Institute of Technology under the direction of Dr. C. S. Draper, FIAS. . . . An electro-hydraulic control system for high-thrust turbojet engines has been developed by the Aeronautical Division. This "coordinated" jet-engine control system ties together all of the jet-engine control variables (i.e., speed, temperature, area, and pressure) into a planned control operation that adjusts primary and secondary full flows and the nozzle area to provide optimum engine performance under all speed, altitude, and ambient conditions. This system weighs 100 lbs. . . A new fuel measuring system in which transistors have replaced vacuum tubes has been developed by the Aeronautical Division. Tests are said to have proved the new system to indicate accurately from −67°F. to +165°F. The indicator and power unit have been hermetically sealed in a single case. The system, the company reported, is approximately 75 per cent lighter and 86 per cent smaller and uses half as much power as systems of comparable accuracy using vacuum tubes.

• **North American Aviation, Inc. . . .** The company's participation in the atomic energy field was referred to in an address delivered on March 25 by Eugene M. Zuckert, a Member of the U.S. Atomic Energy Commission, before the National Industrial Conference Board's Second California Meeting. In the talk entitled "AEC's Nuclear Power Development Plans," Mr. Zuckert stated that: "This [North American's part in the AEC program] involves the sodium-graphite technology that North American has been studying for some time. It would combine the sodium as a coolant and graphite as a moderator, giving us the advantage of high temperature without a high pressure. We have decided to go ahead with a reactor designed to produce about 20,000 kw. of heat but without any equipment attached to convert the heat to electricity. It is a pleasure to be able to say this afternoon that North American and the AEC have reached an agreement to share the responsibility of this experiment. The entire project is expected to cost about $10 million, including the cost of a site, research and development, construction, and an operation test program of two years. North American will assume $2.5 million of the cost of the program, including the site, housing and utilities necessary for the reactor experiment. The project will be completed in 1958.". . .An atomic energy "catalog" has been released by North American. This publication, "Nuclear

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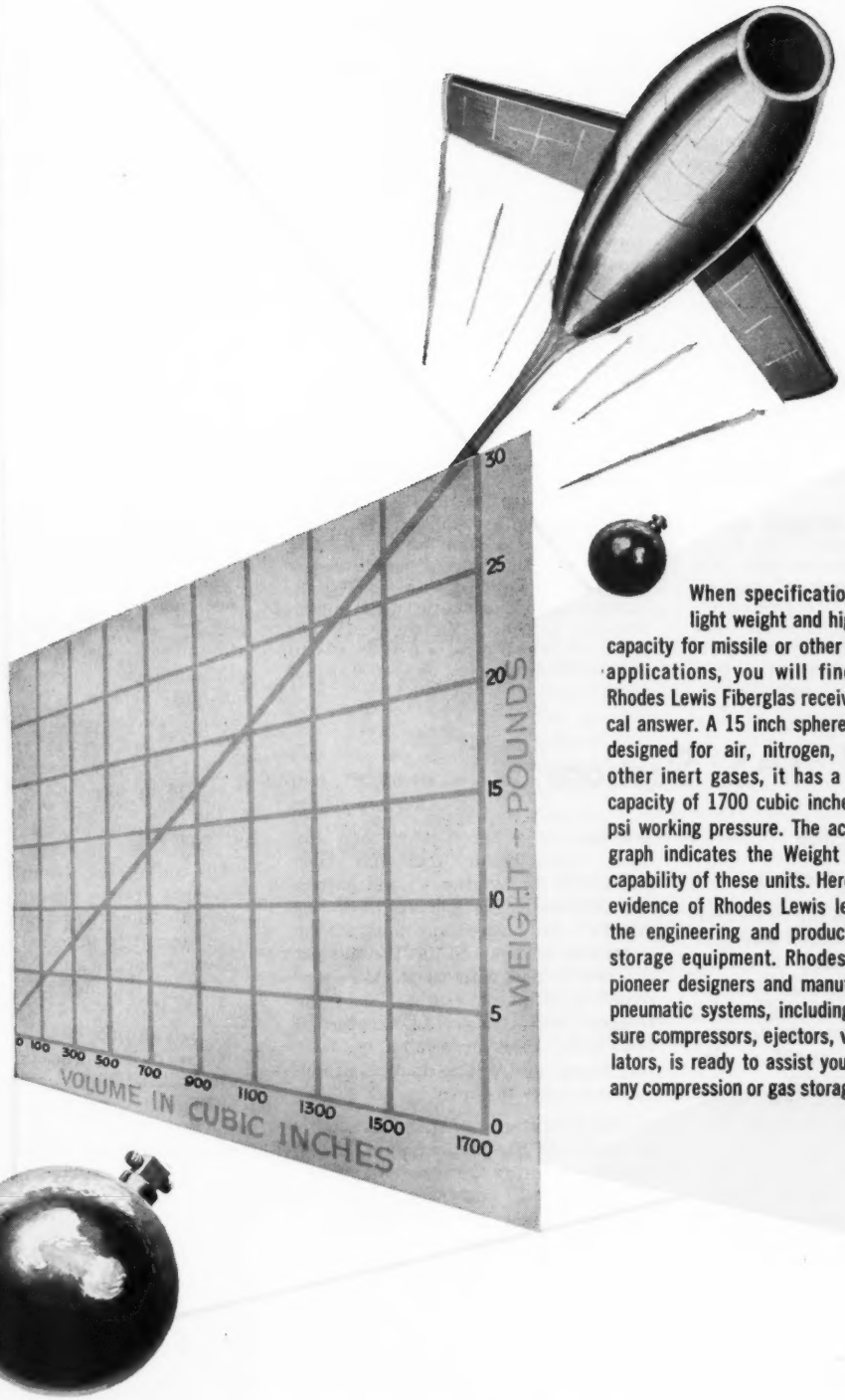
WEIGHT COUNTS



When specifications call for light weight and high pressure capacity for missile or other expendable applications, you will find the new Rhodes Lewis Fiberglas receiver the logical answer. A 15 inch sphere, especially designed for air, nitrogen, helium and other inert gases, it has a volumetric capacity of 1700 cubic inches for 3000 psi working pressure. The accompanying graph indicates the Weight vs. Volume capability of these units. Here is striking evidence of Rhodes Lewis leadership in the engineering and production of gas storage equipment. Rhodes Lewis Co., pioneer designers and manufacturers of pneumatic systems, including high pressure compressors, ejectors, valves, regulators, is ready to assist you in meeting any compression or gas storage problems.

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Reactors for Science and Industry," describes the three basic types of research reactors that the company is prepared to design and build for qualified scientific and industrial groups. The reactors described are the solution, pool, and homogeneous graphite types that can be used as the basis for reactor designs to meet specialized nuclear research requirements.

• **Pan American World Airways, Inc. . . .** Beginning on May 1, the installment-buying principle was introduced by Pan American into air transportation. Known as the "Pan Am Pay Later Plan," it provides for a 10 per cent down payment and the balance in up to 20 monthly payments thereafter. Credit under this plan, which is available at all Pan American U.S. offices and authorized travel agency locations, may be granted to cover all international travel over the routes of Pan American and its affiliate carriers. . . . A 12-page booklet entitled "How to Clear U.S. Customs the Easiest Way" has been published by Pan American. It is offered free at any Pan American office in the country or can be obtained by writing the company's Sales Promotion Department, 28-19 Bridge Plaza North, Long Island City 1, N.Y.

• **Ryan Aeronautical Company. . .** The company recently announced that it was entering into a new production field. The exact nature of the work is classified; however, it was said that large components of stainless steel and aluminum are to be fabricated and that an entirely new department is being set up to handle the confidential project. . . .An Electronic Computing Section has been established as an aid to Ryan's Engineering Division.

• **Seaboard & Western Airlines, Inc. . . .** The company is taking delivery of four new Super Constellation freight aircraft some time this summer. These aircraft can carry a pay load of 18 tons at 300 m.p.h. in transatlantic operation.

• **Sikorsky Aircraft Division, United Aircraft Corporation. . .**Frederick G. Dawson, Executive Assistant at Sikorsky, died on March 8 at his Westport, Conn., home. Mr. Dawson was 61.

• **Thompson Products, Inc. . . .**Dr. Dean E. Wooldridge and Dr. Simon Ramo were recently elected to two new posts on the corporation's Board of Directors. (These new posts raise the Board's membership from nine to eleven.) Dr. Wooldridge is President and Treasurer of Ramo-Wooldridge Corporation, and Dr. Ramo is its Vice-President, Executive Director, and Secretary. These two men organized Ramo-Wooldridge Corporation last year with financial backing provided by Thompson Products.

• **United Air Lines, Inc. . . .**On March 29, the first of United's $58,000,000 order for 25 DC-7 transports was delivered by Douglas Aircraft Company, Inc. This new United DC-7 Mainliner began coast-to-coast nonstop service about the first of this month. Powered with four Wright turbocompound engines turning Hamilton Standard propellers, the ship cruises at 365 m.p.h. with a crew of five, 58 passengers and their baggage, and 9,000 lbs. of cargo.

IAS Sections

Boston Section

E. L. Dashefsky, *Secretary*

The second meeting of the 1953–1954 season of the Boston Section was held on January 28. Preceding the meeting at the Massachusetts Institute of Technology, dinner was served at the Faculty Club. Approximately 50 members and guests were present at the dinner, and 200 at the meeting.

The Boston Section was both privileged and fortunate to have E. H. Heinemann, Chief Engineer of the El Segundo Division of the Douglas Aircraft Company, Inc., as its guest speaker. Mr. Heinemann is an "old timer" in the aviation industry, having begun his career with Douglas in 1926. In 1951, Mr. Heinemann was honored by the IAS with The Sylvanus Albert Reed Award for his contribution in the field of experimental aeronautics. In 1952, he was elected a Vice-President of the IAS.

During his discussion of "Some Problems and Limitations in High Speed Airplanes," Mr. Heinemann made the following comments: "Speed has been and will be for many years to come one of the most important factors in aviation. It is speed more than any other characteristic that has been responsible for aviation's rapid growth and progress. The magnitude of this growth is emphasized in comparing the 30-mile-an-hour speed of the Wright Brothers in 1903 with the world's speed record of 753 m.p.h. established by the Douglas Skyray Navy interceptor 50 years later. This increase . . . has been very steady and will no doubt continue for some years to come.

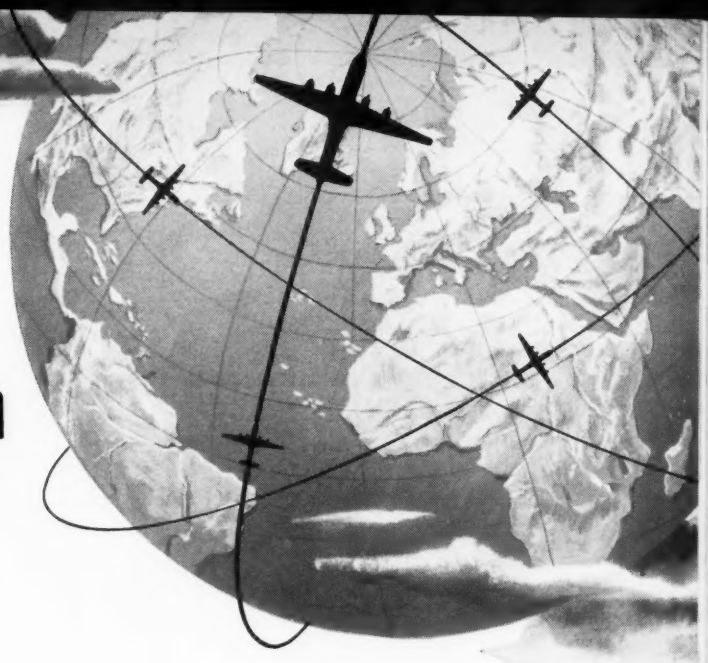
"The importance of speed in a military airplane has been unquestionably established during the recent wars, and in the world of commercial transportation, the airplane has proven beyond a doubt to be the most popular, efficient, and fastest means of transportation for both personnel and cargo. During 1953, the world's airlines transported 52,000,000 passengers and a cargo volume aggregating 700,000,000 ton-miles. All this was done in less than a quarter of the time required by surface transportation. With such strong stimulation, there is every indication that speeds will continue to increase until limited by either physical or economic conditions. Just how and when these limitations will occur is, of course, a matter of great speculation. But in the absence of a sure and sound method of predicting future progress, it certainly seems basic and fundamental to project the progress of the past into the future to try to predict what the future may hold.

"Airplane world-speed records have during the past 50 years, increased at only slightly more than 14 miles per year. At the same time, passenger-carrying propeller-driven transport cruising speeds have increased at approximately half that rate. The big question now in the minds of the aviation public is, 'how fast will jet transports cruise and what will their rate of increase be?' From the published data of passenger-carrying transports under development, a new trend appears to be taking form at about the same rate of increase, but about 100 m.p.h. faster than propeller-driven aircraft. A more rapid increase in speed is, of course, possible, but does not appear practical due to economic considerations.

"In the field of rocket planes and missiles, particularly uninhabited ones, much greater progress in speed has been made. Speeds for rocket-propelled vehicles are essentially unlimited, especially when operating outside the atmosphere. The great problem in utilizing rocket power for high-speed inhabited vehicles is the aerodynamic heating encountered when returning into the atmosphere at very high speeds. In the last 25 years, rocket vehicles have increased in speed to 5,000 m.p.h., or at the rate approximately of 200 miles per year.

"In considering the future trends of maximum speeds in aircraft, it is essential to define the supporting medium. If an aircraft is airborne and operating within the earth's atmosphere, it will be subject to the limitations of aerodynamic heating and problems associated with high-altitude flight. On the other hand, a rocket-borne or momentum-borne rocket-type machine is relatively free from these problems except during re-entry into the atmosphere. To illustrate aerodynamic heating with increased speeds, an airplane flying continuously at twice the speed of sound or approximately 1,150 knots will reach a temperature of 200° F. even with an ambient air temperature of −65°F. At the present time with structural materials and equipment available, 200°F. is considered a maximum safe-operating limit. To fly at higher temperatures would require the use of new structural materials and construction methods, as well as a great increase in the amount of refrigeration required to keep inhabitants and equipment cool. At present, it appears quite difficult and impractical to provide any large increase in cooling.

Eclipse-Pioneer Polar Path marks a new high in navigation efficiency



New, lightweight compass system provides super-accurate navigation anywhere in the world

Here is a compass system so accurate, so compact, so flexible, and so broad in application that *it may be used as a directional reference on any type operational aircraft anywhere in the world.*

The Eclipse-Pioneer Polar Path is a gyro-compass system that utilizes the same type high-accuracy gyro which so successfully blazed the trail during 1952 in over-the-Pole gyro navigation. Polar Path can be used solely for directional reference, if desired. Or it can be used to provide directional control for an auto pilot, a bomb director, automatic approach system or other device requiring super-accurate directional reference at any latitude.

Among the many important advantages of Eclipse-Pioneer Polar Path are the following:

- **It meets, or betters, the performance and weight requirements of the latest applicable military specifications for compass systems.**
- **It combines the delicate accuracy of a proved gyro navigation system with the long-term reference reliability of a new Flux Gate* transmitter weighing less than one pound.**
- **It is designed for all operational types of aircraft from carrier-based fighters to multi-engine aircraft, including bombers and commercial transports.**
- **The controller, with its functional selector switch, latitude correction scale, and synchronizing and course-setting controls, is compact . . . designed for convenient console mounting and ease of operation.**
- **The Flux Gate system is always available for standby compass when desired.**

As an Eclipse-Pioneer development, Polar Path is engineered and manufactured by the world's largest producer of precision gyros for aircraft use. Gyros of the super-accurate type used in Polar Path have for some time been *mass-produced* by Eclipse-Pioneer. And it is super-accuracy . . . plus great flexibility . . . that mark Polar Path as the *modern* compass navigation system. For full details, write us today.

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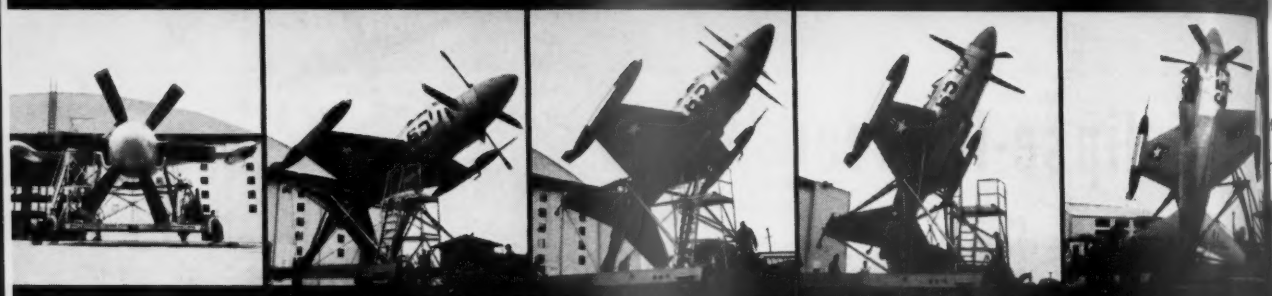

SPECIAL CRADLE LIFTS XFV-1 from prone position (for servicing) to upright for vertical takeoff.

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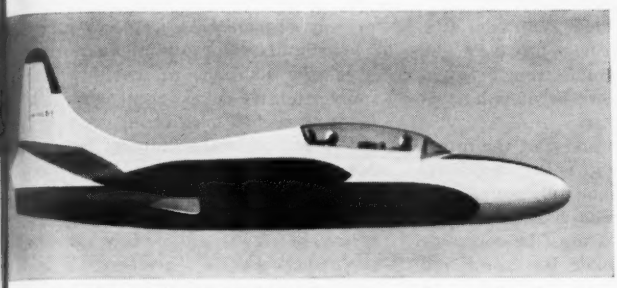


RLD'S SAFEST JET AIRPLANE. Greater power, larger cockpit, but, above ove safety have been engineered by Lockheed into its new jet trainer. New stall slats, chute, Zero Reader and pilot "stick shaker" device to automatically warn about ble stall are just a few of added safety features. Trainer combines jet combat perform- with maximum operational safety. Easier to fly than simple propeller-driven trainers.

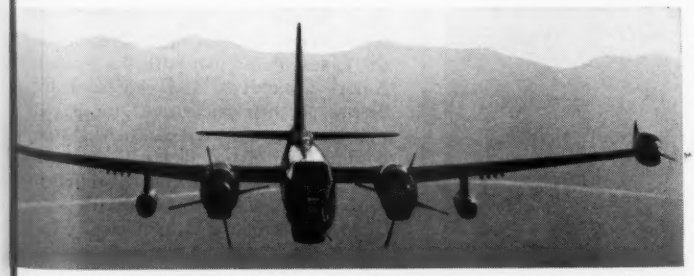
GUIDED MISSILE and pilotless aircraft research is advancing rapidly at Lockheed. Here engineer-scientists from the Missile Systems Division test top-secret developments to meet problem of supersonic speeds yet unattained.

edcientists Unveil Radical Forms of Flight

h-Speed Navy Fighter Takes Off Straight Up, Lands by Backing Straight Down on Its Tail

y's biggest news in aviation is the 's XFV-1 built by Lockheed, a rev- nary new vertical-rising plane. powerful Allison turbo-prop engine two jet turbines turning counter- ng propellers lifts XFV-1 straight ocket fashion. It levels off for speeds e 500-m.p.h. class, lands on its tail. ny Lockheed "firsts" are built into irplane. A ¼-scale model powered by a 76-h.p. electric motor was built and flown to test vertical ascent, transition into level flight, and landing. Careful weight control permitted completion of first prototype hundreds of pounds less than estimated weight for Navy requirements.

Unique 4-way tail serves as a single surface and jointly functions as elevator, aileron and rudder, using revolutionary interlocking controls.



ND ENGINEERING pays off with Lockheed P2V Navy patrol bomber. The famous ne has increased gross takeoff weight and boosted speed by adding powerful jet pods. ne's aerodynamic configuration, however, remains unchanged from original X model 11 go through the current 7 series.

FIRST ROUND-THE-CLOCK flying radar station in the world is this Lockheed Early Warning Aircraft (designated WV-2 by Navy and RC-121C by Air Force). Huge 600-gallon tip-tanks extend radar-laden Super Constellation's range. Plane carries more scientific equipment than any other known aircraft—some six tons of electronics. Bottom radome, the size of a swimming pool, is largest plastic part ever built. Although it is held to plane by only 10 bolts (no metal ribs), radome is built to withstand aerodynamic pull of up to 60,000 pounds. Super Constellation's three-tail design insures aircraft controllability despite air-flow disturbance created by protruding radomes.

ockheed

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OK TO LOCKHEED
LEADERSHIP

NEW FLIGHT FORMS are studied by Lockheed scientists to meet sonic and thermal problems of ultra-high speed, higher altitudes. Nearly a decade of research on wing shapes alone results in new Lockheed forms in Mach 2 to Mach 3 range. Lockheed has tested almost 100 distinctly different wing models on supersonic rockets.

"The effect of high temperatures on the strength of present aircraft materials is illustrated by the following data. At a temperature of 200°, which occurs at about 1.2 times the speed of sound at sea level, the strength of the common 75ST aluminum structural alloy is reduced by 10 per cent. At 300° or about 1.6 times the speed of sound at sea level, the strength of this same alloy is down to only 40 per cent of its normal strength. The strength of acrylic resins, such as those used in cockpit enclosures, drops off to zero at even less than 200° at a speed of only slightly greater than 700 m.p.h. Stainless steels, common chrome molybdenum steels, and titanium alloys do not drop off so rapidly and can be used satisfactorily at supersonic speeds. These materials, however, have some weight, manufacturing, and procurement disadvantages that make them less desirable. Of these three materials, titanium shows the greatest promise, since it is the most favorable from a weight point of view. However, it is not yet readily available.

"While it can be said that the future of high-speed aircraft is very good and progress will continue substantially as it has in the recent past, there are many problems that must be overcome as demands are made for faster and higher flying aircraft. Some of these problems of high-speed and high-altitude stalls, temperature limits, and combustion limits are all very real and great and, for the time being at least, tend to limit the sphere of operation of present airplanes as we know them. These limits point toward many problems, the solutions to which will require extensive development work in all fields of aircraft engineering."

For a considerable number of years, Mr. Heinemann has ardently campaigned for the improvement in aircraft performance by the elimination of weight, particularly where unnecessary equipment is concerned. It is a most significant fact that the last six models of aircraft turned out by Mr. Heinemann and his associates at El Segundo were 42 per cent lighter than the nearest competitive airplanes, and in all cases but one, exhibited superior performance. Mr. Heinemann illustrated how a pound increase in structure and equipment weight cost about $400.

A question-and-answer period for approximately 30 minutes followed this interesting and enlightening talk. The meeting adjourned at approximately 9:45 p.m.

Chicago Section

Leland W. Sims, *Secretary*

On March 24, the Chicago Section held its Fourth Annual Student Meeting, and the second of this type. Last year, the student members were approached to determine the type of program that they would like to have for their annual meeting. Student representatives of the Student Branches in the Chicago area met with the Student Affairs Committee and expressed the desires of their respective groups. It was unanimously agreed that a symposium type of program with three or four speakers representing different fields of application, but speaking on a common theme, was preferred. The program last year met with such success that it was decided to continue this procedure in the future.

This year, the Student Branches at the Aeronautical University, University of Illinois in Chicago, and the Illinois Institute of Technology were responsible for making all plans and arrangements, including those for speakers, transportation, and conducting the meeting.

One hundred and seventy-seven people were served dinner in the cafeteria of the Museum of Science and Industry. Two hundred and seventy-eight members and guests attended the meeting which began at 7:30 p.m. in the Museum Auditorium. The theme of the program was "The Development of the Design and Per-

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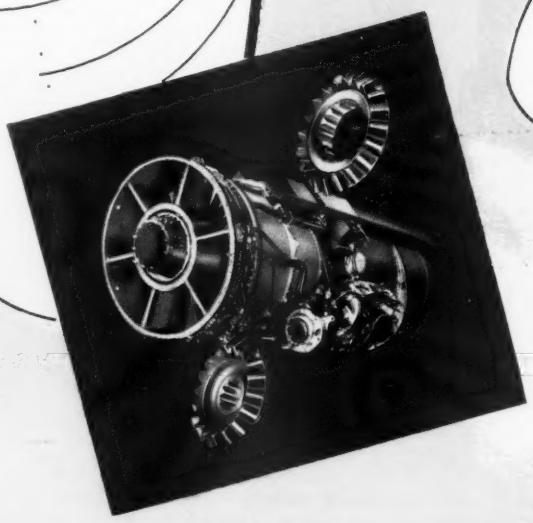

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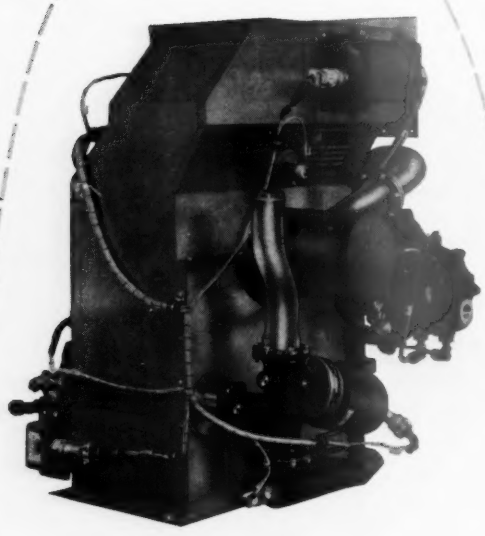

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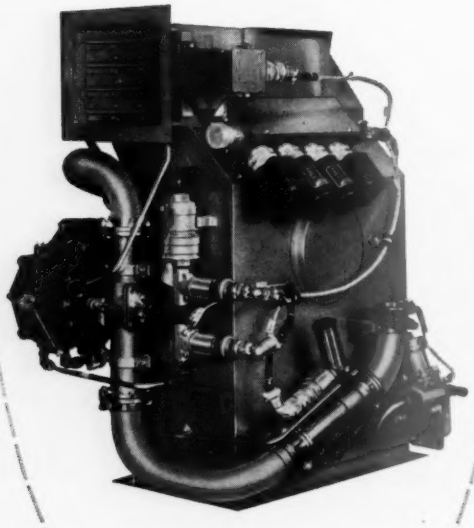
Janitrol Purge Gas Generator



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The generator pictured on the opposite page—for a new jet aircraft—is one of several models that have been undergoing steady development since 1949, based on the proven theory that combustion is the most economical and efficient method of supplying large quantities of inert gas for aircraft protection.

The Janitrol unit weighs less than 90 pounds—occupies only 3 cubic feet—produces more than 10 lbs./min. of inert gas for complete, passive, explosion and fire defense from "natural" causes as well as enemy action. The pilot need flip only one switch to set the generator into operation, from there on operation is automatic and continuous. Generated gas is dumped overboard until the proper degree of "inertness" is established, then the gas is supplied to fuel cells and surrounding area on a demand basis—

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The versatility of Janitrol's new "dimple-plate" heat exchanger principle permits construction of generators in virtually any configuration to meet installation requirements on planned, as well as existing aircraft.

Inquiries relative to civil aviation applications are invited.

37 years experience in combustion engineering

Janitrol

AIRCRAFT-AUTOMOTIVE DIVISION
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Speakers at the Chicago Section's Fourth Annual Student Meeting on March 14 were: *upper left,* Major Charles E. Yeager, USAF; *upper right,* Steven S. Wittman; *lower left,* First Lt. Howard C. Ramstad, USAF; and *lower right,* William C. Mentzer.

formance of Aircraft," with four categories of aircraft represented. These were Commercial Aircraft, World War II and Korean Military Aircraft, Civilian Racing Aircraft, and High-Speed Research Aircraft.

The meeting was called to order by the Chicago Section Chairman, Alfred F. Stott, Dean of Engineering, the Aeronautical University. Mr. Stott welcomed all in attendance and had groups of students from the University of Notre Dame, Illinois Institute of Technology, Aeronautical University, University of Illinois in Chicago, University of Illinois in Urbana, and the Lewis College of Science and Technology stand up and be recognized.

Mr. Stott then introduced Don Goldman, the Student Chairman for the evening, who is a Student Member from the Illinois Institute of Technology. Mr. Goldman introduced Masami Terada, of the Aeronautical University, who introduced the first speaker, William C. Mentzer, General Manager, Engineering, of United Air Lines. Mr. Mentzer spoke on Commercial Aircraft. He traced the development of commercial transports, showing with slides the major changes in design in each successive model and commenting on the performance increases for each. Mr. Mentzer also spoke on the future possibilities of various types of jet transports.

Mr. Goldman then called on Philip Meyer, from the University of Illinois in Chicago, to introduce Steve Wittman, who spoke on civilian racing aircraft. Mr. Wittman gave a complete progress report on all major air races, foreign and American, showing the manner in which speeds had fluctuated from year to year, but generally had increased. Mr. Wittman also illustrated the contribution of racing pilots and designers to the general progress of aviation, both civilian and military.

Mr. Goldman then brought out James Siller, of the Aeronautical University, to introduce the third speaker, 1st Lt. Howard C. Ramstad, USAF, Assistant Professor of Air Science and Tactics at the Illinois Institute of Technology. Lieutenant Ramstad recounted his experiences with World War II reciprocating-powered aircraft, emphasizing their performance characteristics. He described his transition to jet aircraft, giving the major differences in performance and handling from a pilot's viewpoint.

The final speaker, Major Charles E. (Chuck) Yeager, USAF, was introduced by Vic Serafini of the University of Illinois in Chicago. Major Yeager spoke on "High Speed Research Aircraft." He described the operations of the Air Force Flight Test Center at Edwards AFB, Edwards, Calif. He gave some of his experiences with the Bell X-1, explaining the steps that were followed in the sequence of tests made with this aircraft. He described his take-off with the Bell X-1 and his climb to altitude. Major Yeager was the first pilot to break the sonic barrier and has flown to a speed of 1,650 m.p.h. in the Bell X-1A.

Mr. Goldman then turned the meeting over to Chairman Stott. Mr. Stott introduced Leland W. Sims, Chairman of the Student Affairs Committee, who thanked all participating Student Members and the Student Branches in the Chicago area for their efforts in making such a fine program possible.

Mr. Stott adjourned the meeting with thanks to all speakers and participants at 10:45 p.m.

Hagerstown Section

George W. Westphal
Secretary-Treasurer

The meeting of March 24 was held in the Packet Room of the Terrace Restaurant. Chairman R. A. Darby presided; total attendance was 19.

Mr. Darby introduced Jeffrey W. Lewis, Sales Representative, Washington Office, American Airlines, Inc. Mr. Lewis then introduced the speaker of the evening, Thomas J. Harris, Manager of Cargo Sales, American Airlines.

Mr. Harris discussed some of the marketing and distribution problems associated with the movement of freight by air and pointed out some of the problems involved in selling airfreight. A lively question-and-answer period followed the main discussion.

The meeting was adjourned at 10:45 p.m.

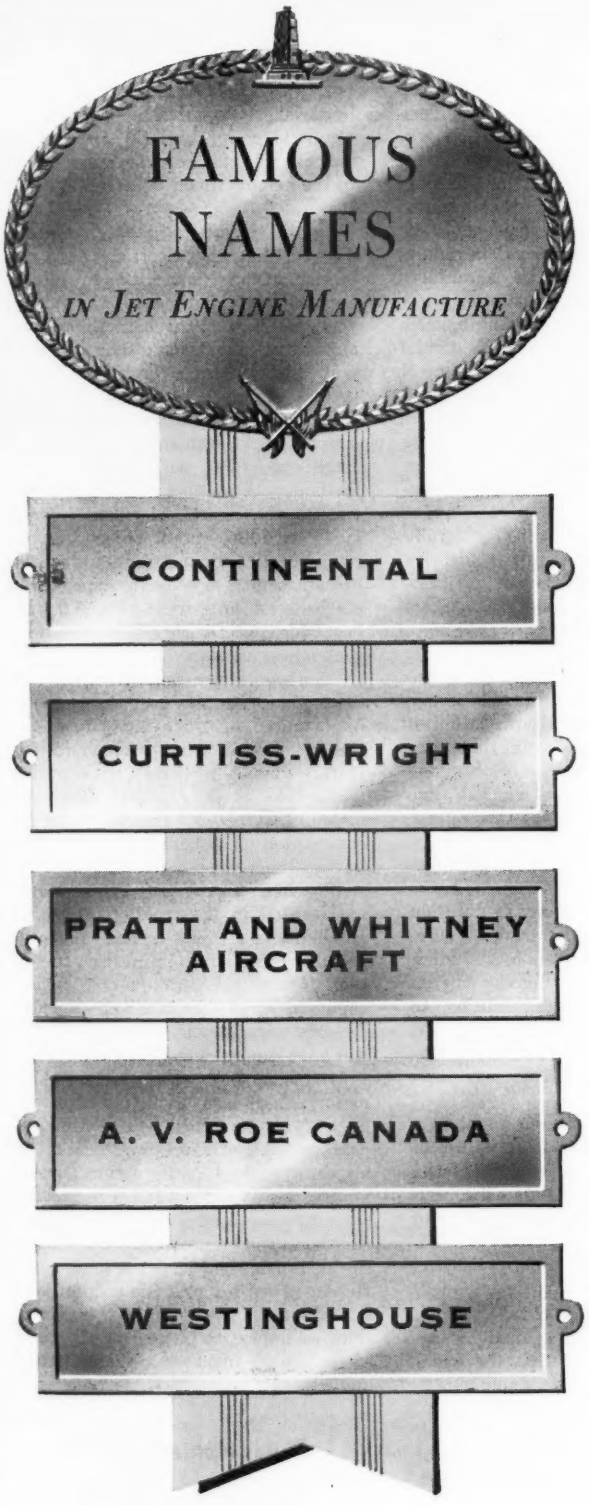
Los Angeles Section

Evert C. Hokanson, *Secretary*

Major General Albert O. Boyd, USAF, Commanding General, Wright Air Development Center, gave the Los Angeles Section both fact and fantasy in an exceptionally interesting classified meeting held on March 18.

The fact that General Boyd was the speaker and his subject was "The MIG-15," resulted in a capacity attendance of 315 for dinner and over 600 for the meeting. Even though processing security clearances for this large number resulted in some delay, everyone in attendance felt well rewarded for his waiting as General Boyd presented a fascinating and thought-provoking program. His evaluation of the MIG-15 in terms of research and development requirements was based on flight tests. His talk, supplemented by sound movies of the tests, kept everyone's interest at high pitch from beginning to end. An anonymous hilarous movie about a squadron receiving its first Sabre jets provided good entertainment in the lighter vain.

R. Richard Heppe, Section Chairman, presided at this meeting which was the largest in our history. He expressed the Section's deep appreciation to Col. Daniel Cooper and his staff, under Mr. Taylor, who so ably handled the difficult security procedures. Another major



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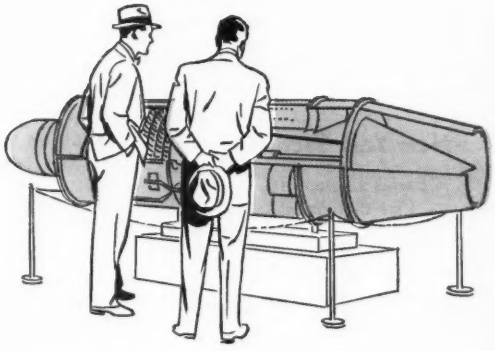

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contribution to this meeting was the work done by the Institute staff and members who assisted with the checking of clearance papers and individuals.

▶ Dr. Mac C. Adams, Aerodynamics Group, Douglas Aircraft Company, gave a paper "A Review of Slender Body Theory-Wings, Bodies and Wing-Body Combinations" to a Specialist Meeting held on March 11. Dr. Adams presented an excellent survey of the theory as applied to low-aspect-ratio wings, bodies, and wing-body combinations with emphasis on results without mathematical detail. A number of interesting points were added during the discussion period.

▶ William E. Braham, Chief Engineer, Zenith Plastics Company, presented a paper on "Reinforced Plastics in the Aircraft Industry" on March 23 to an audience of 118 people. The use of reinforced plastics in load-carrying structural members of the air frame plus the application in the electronics field were discussed in detail. Samples of reinforced plastics, slides showing structural qualities, and a film depicting manufacturing methods were presented.

New York Section

Charles Tilgner, Jr.,
Vice-Chairman

T. F. Hammen, Jr.
Secretary-Treasurer

A well-attended and highly interesting meeting on the subject of "Atomic Energy Applications" was held at Grumman Aircraft Engineering Corporation on March 11. This meeting, which followed the social period and dinner, was opened by Charles Tilgner, Jr., and chairmanned by Prof. F. K. Teichmann. The speakers were Dr. Paul C. Aebersold, Director, Isotopes Division, Oak Ridge Operations, Atomic Energy Commission; Dr. R. P. Petersen, Chief, Industrial & Production Reactors Branch, Division of Reactor Development, Atomic Energy Commission; and Abe Silverstein, Associate Director, Lewis Flight Propulsion Laboratory, NACA. Summaries of the presentations are given below.

"*The Uses of Radioactive Isotopes in Industry.*"—Dr. Aebersold started his discussion of the application of radioisotopes by pointing out that, of nearly 800 industrial firms now using radioisotopes, not more than 24 were directly associated with the aircraft industry. He expressed hope that his presentation would help to expand their use in the aircraft industry. He observed that radioisotopes can be used as sources of radiation and as tracer atoms and that their utility stems from their sensitivity and specificity of measurement and versatility of application.

Dr. Aebersold pointed out that the applications could be broadly divided into radiography, gaging, marking, studying wear, research, and miscellaneous applications. Although he emphasized the routine applications, he pointed out that research uses were probably more important on the long-range basis. It was further pointed out that radioactive cobalt could be made stronger and cheaper than radium and that in radiography the advantages of availability, ease of handling, low cost, portability, and no maintenance were significant. He discussed the application to routine quality control in the smaller industries. It involved foundries and field work, such as the inspection of welded pipe lines. He said that a number of aircraft concerns were using this application to radiography.

Radioisotopes are being generally applied to thickness gagings, density measurements, liquid height determination, leak detectors and as markers for the change in products in pipe lines. Of particular interest to the aircraft industry was the discussion of the application of measuring air density in wind tunnels and the determination of piston-ring wear rates. In the latter case, the increase in speed of obtaining results by twenty times and a time saving of almost thirty times were mentioned.

In research, the application of radioisotopes to materials testing, to the measurement of such things as diffusion coefficients, and in the field of aeromedical research to metabolism studies, etc., were mentioned. In the miscellaneous category, the application to radioactive batteries of high-voltage and low-current output for use in instrumentation and communications was indicated.

In closing, Dr. Aebersold noted that industry is rapidly increasing its use of the radioisotopes, stating that the shipments of such materials have been steadily increased from scratch in 1946 to more than 10,000 shipments in 1953. He stated that direct use by the aircraft industry could be greatly extended.

"*Program for Industrial Atomic Power.*"—Dr. Petersen opened his remarks by pointing out that the widespread use of industrial atomic power depended on three things—can, may, and shall, with the first depending upon scientists and engineers; the second, upon legislators; and the third, upon management and financiers.

He said that the present cost of electrical power varied from 2 to 9 mills, with the average being 6 mills per kwh. of which the fuel cost was approximately 3 mills per kwh. He stated that the real hope for advantageous use of atomic power was from the standpoint of fuel cost, with a reduction from 3 mills to 1 mill being considered feasible. It was pointed out that size was another factor and was illustrated in two ways: (1) 1 Gm. of radioactive material would produce 6,000 kwh. of electrical power, and (2) a reactor the size of a file case would replace a boiler in the neighborhood of 80 by 80 by 100 ft.

Dr. Petersen noted that some studies showed that the electrical power requirements are expected to increase approximately 5 times in the next 50 years and that on this basis the required amount of conventional fuel would present a considerable problem. It was predicted that the amount of electric power currently being produced by conventional methods could be duplicated by 1980 with nuclear-energy methods. A number of proposed electric power plants of nuclear-energy type, including one of 60,000-kw. output, were mentioned. He stated that private capital was being expended at the rate of approximately $5,000,000 per year toward the development of such power plants.

"*Nuclear Power for Aircraft.*"—Mr. Silverstein started by showing the importance of high-thrust-to-engine-weight ratio in high-performance aircraft. This is available with nuclear power, and several systems were shown, including a turbojet engine having the combustion chamber replaced with a nuclear reactor, or better yet, a similar arrangement except that a liquid coolant is used in the reactor. Also, the possibility of a steam-turbine condenser was discussed. It is interesting to note that, unlike the internal-combustion-engine-powered airplane, a nuclear-powered airplane, if it will fly at all, will have ample range.

Mr. Silverstein then went into the materials problem, discussing corrosion, ductility, mass transfer, and radiation damage. Also discussed was heat transfer, showing the superior performance of molten metals, with water a reasonable second choice, and gases a poor third. Another airplane problem is the reactor shield, which must be dense and heavy. He closed with a plea for prompt consideration of the problems involved, since we appear to be nearing the point where a nuclear-power airplane can be built.

Philadelphia Section

Emily R. Gibbs, *Secretary*

A meeting of the Philadelphia Section, held on Wednesday, March 3, featured Dr. Nicholas J. Hoff, who spoke on "The Thermal Barrier." Dr. Hoff, who is Head of the Department of Aeronautical Engineering and Applied Mechanics at the Polytechnic Institute of Brooklyn, delivered the Forty-First

NEW PROTECTIVE COATING CHEMICAL FOR ALUMINUM

ALODIZING

Alodizing with "Alodine,"* a new technique in the protective coating of aluminum, was made available for production-scale use in 1946. Since that time Alodizing has largely supplanted the more elaborate, costly and time-consuming anodic treatments in the aircraft and other industries.

Continuous and successful industrial use has clearly demonstrated the simplicity and economy of the Alodizing process as well as the effectiveness of the "Alodine" amorphous coatings, particularly as a base for paint. In fact, the paint-bond that Alodized aluminum provides has been found to be superior to that possible with chromic acid anodizing.

The corrosion-resistance of unpainted aluminum Alodized with "Alodine" Nos. 100 or 300 is excellent, easily meeting the requirements of Specification MIL-C-5541. However, a need for protection of unpainted aluminum, even better than that obtained with chromic acid anodizing, has long been recognized.

NEW IMPROVED "ALODINE" DEVELOPED By ACP RESEARCH CHEMISTS

Several years of intensive research have now led to a new type of "Alodine," designated as "Alodine" No. 1200. This new protective coating chemical forms an amorphous mixed metallic oxide coating of low dielectric resistance that provides unusually high corrosion-resistance for unpainted aluminum. In addition, it forms an excellent paint bond that approaches closely the high quality obtained with the earlier types of "Alodine."

After having been tested for conformance with Specification MIL-C-5541, "Alodine" No. 1200 is now about to go into production.

PROCESS DETAILS

"Alodine" No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath. One of its unique features is that it can be used in tanks in an immersion process, or, in a multi-stage power washer in a spray process, or, with a slight adjustment of pH, with brush or portable spray equipment in a manual process. This means that even where the simple production equipment is not available, or where touching up of damaged coatings previously Alodized or anodized is required, excellent protection and paint bonding can still be obtained with practically no equipment.

All three methods of application easily meet the requirements of Specification MIL-C-5541.

Process sequence for all three methods of application is the same as for other standard grades of "Alodine" such as Nos. 100, 300, and 600, viz.: 1. Pre-cleaning. 2. Rinsing. 3. Alodizing. 4. Rinsing. 5. Acidulated rinsing. 6. Drying.

Coating time in an immersion process ranges from 2 to 8 minutes and in a mechanized spray process is about 30 seconds. "Alodine" No. 1200 baths are operated at room temperatures (70° to 100°F.) and heating is required only if the bath has gotten cold after a "down" period.

RECOMMENDED USES FOR "ALODINE" No. 1200

"Alodine" No. 1200 is specifically recommended for coating wrought products that are not to be painted or are to be only partially painted; and for coating casting and forging alloys whether or not these are to be painted. "Alodine" Nos. 100 and 300 are still recommended for coating wrought products such as venetian blind slats, awnings, etc., that are invariably painted.

RESULTS OF TENSILE TESTS

This new "Alodine" not only retards visible corrosion and pitting, but as shown in the table below, the loss of ductility with "Alodine" No. 1200, both brush and dip after 1000 hours salt spray was less than for chromic acid anodizing after 250 hours, and for "Alodine" No. 100 and a conventional chromate treatment after 168 hours exposure.

PROCESS	SALT SPRAY EXPOSURE	COMPLIANCE WITH TENSILE REQUIREMENTS OF MIL-C-5541
CHROMIC ACID ANODIZING	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	fails
	1000 hrs.	fails
BRUSH "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 100	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails
CONVENTIONAL CHROMATE TREATMENT	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails

"Alodine" Trade Mark Reg. U. S. Pat. Off.

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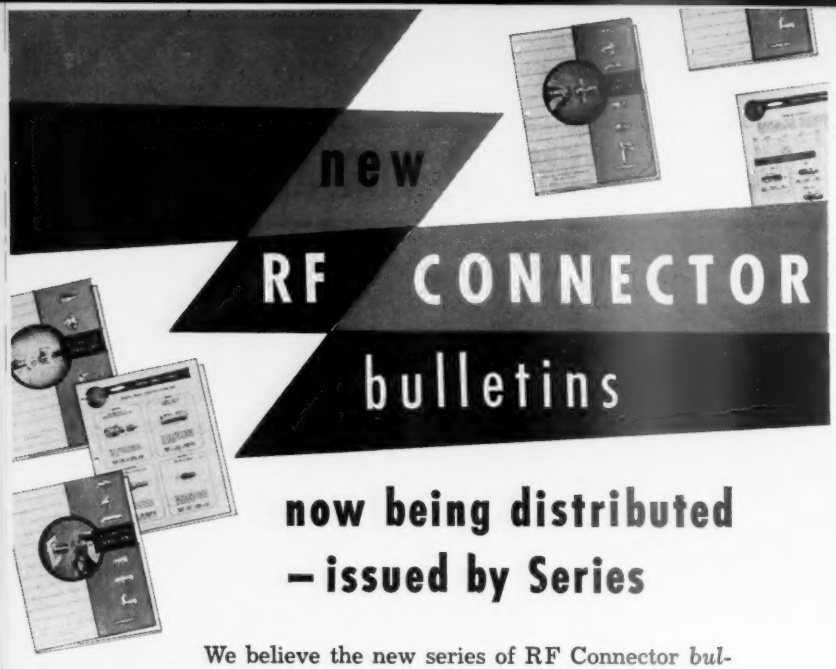

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Wilbur Wright Memorial Lecture at the invitation of the Royal Aeronautical Society during the Fourth International Aeronautical Conference in London last September. He has had an enviable career serving the profession in many capacities, a few of which have been as Vice-Chairman of the United States National Committee of Theoretical and Applied Mechanics, member of the Structures Sub-Committee of the NACA, member of the Editorial Committee, Fellow of the IAS, and Fellow of the Royal Aeronautical Society of Great Britain. In 1949, he received the Medal of the Engineering Society of Sweden in Stockholm. A summary of his fine talk, which was illustrated with slides, follows:

"At high supersonic speeds the transformation of the kinetic energy of the airflow into heat energy at the surface of a wing or a fuselage of aircraft causes a substantial rise in the temperature of the structure. At the resulting elevated temperatures, structural metals develop plastic and creep deformations under comparatively small loads. One of the most important effects of the nonuniform temperatures is the buckling of all thin elements in consequence of thermal stresses. Another is the continuing deformation of structural elements under constant load which is designated as creep. A tensile bar fractures if the load acts upon it for a sufficiently long time; similarly, there is a critical time at which a column buckles, even if the compressive load applied to it is less than the critical load.

"These new types of problems as well as the aero-medial aspects of aerodynamic heating add up to what is sometimes called the thermal barrier. In the true sense of the word, a barrier is an obstacle which may be hard to overcome, but is not a rigid wall upon which all hopes for increased speeds will shatter."

San Diego Section

H. C. Matteson, *Secretary*

"Aircraft Applications of Titanium" was the subject for a panel discussion held on the evening of March 9 at the Institute Building in San Diego. Moderator for the evening was R. P. White, of Convair, San Diego. Members of the panel were S. R. Carpenter, S. S. Williams, and E. D. Greene from Convair's Manufacturing and Tool Development departments, and J. R. Fullerton from Ryan's Engineering Department.

The members of the panel offered their audience a broad view of the subject, including a brief historical review of titanium, a discussion of its unique physical properties and attend-

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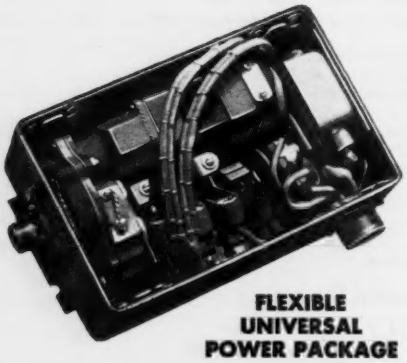
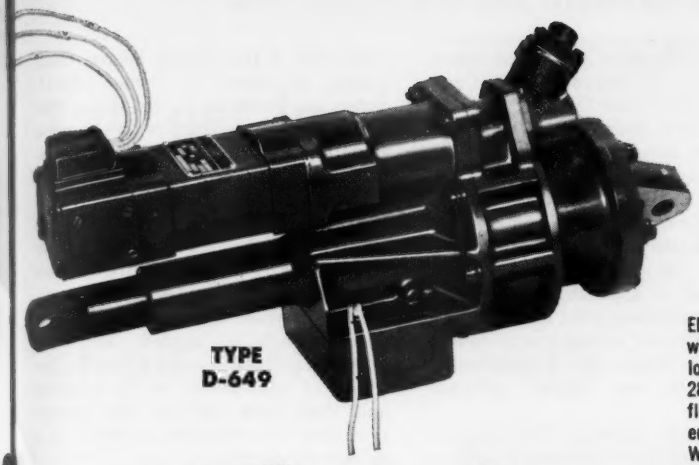
Illustrated at right is a group of EEMCO actuators designed for aileron, elevator and trim tab controls. Powered by the EEMCO Universal Power Package they can be operated singly or in groups to actuate systems — a cowl flap for example. These and many other custom designed EEMCO linear actuators can be adapted for specific purposes with a minimum of expense and delivery time.

EEMCO's flexible Universal Power Package drives single or multiple screw jack actuators, either rotary or linear (some of which are illustrated at right), with direct or flexible shaft connection for remote operation. This compact 3⅜ lb. power package is only 7⅛″ x 4¾₁₆″ x 2¾″ in size yet contains motor, radio noise filter, magnetic clutch and brake, reduction gear and auxiliary gears operating adjustable limit switches to control travel, light switches and position indicator. Specifications can be changed to suit special requirements.

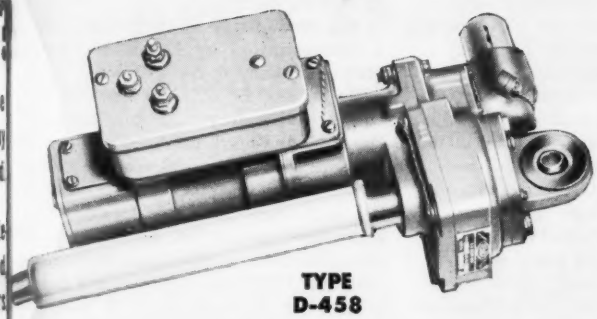


FLEXIBLE UNIVERSAL POWER PACKAGE



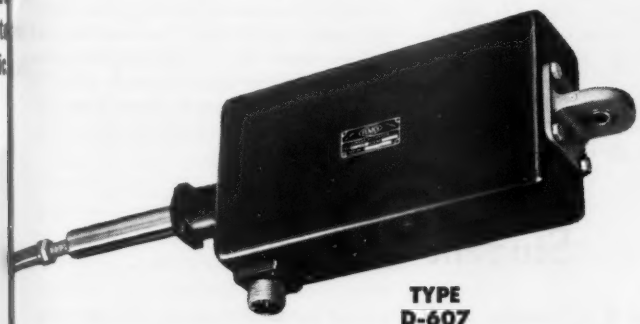
TYPE
D-649

EEMCO's Type D-649 linear actuator weighs 13.75 lbs., and operates with a stroke of 3¾" at .55 inch per second under a working load of 3400 lbs. normal tension and 8200 lbs. peak tension on a 28 volt DC system. Maximum static load is 18,750 lbs. It has a flexible shaft drive take-off, load limit switches, non-jamming end stops and a retraction stop that adjusts to within ¼ inch. With minimum expense and delivery time EEMCO's Type D-649 can be supplied for various loads, lengths of stroke, rates of travel and other characteristics.



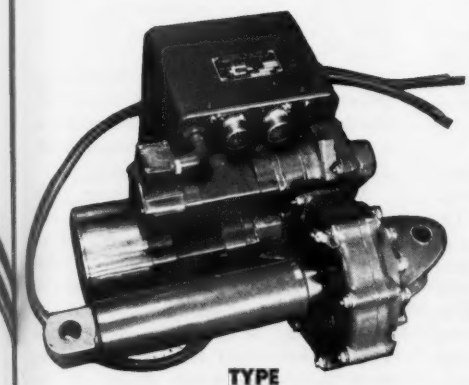
TYPE
D-458

EEMCO's Type D-458 linear actuator for jet wing flaps weighs 8 lbs., 3 oz., has a stroke of 5.14" at .4" per second on 28 volt DC system under a normal load of 3000 lbs. Ultimate static load is 10,000 lbs. compression in fully extended position. Type D-458 has non-jamming end stops, provision for power take-off or hand drive (right angle) and radio noise filter. Load, stroke, rate of travel and other features of EEMCO's Type D-458 can be changed to suit specific needs in a minimum of time.



TYPE
D-607

EEMCO's Type D-607 is a door actuator for transport aircraft which weighs 4.5 lbs. and has a stroke of 6.25 inches. Linear rate of travel is .33" per second at the rated load of 450 lbs. compression. Ultimate static tension load is 7000 lbs. EEMCO's Type D-607 has non-jamming end stops, adjustable travel-limit switches, radio noise filter and operates on a 28 volt DC system.



TYPE
R-129

EEMCO's Type R-129 is a stabilizer actuator for large jet fighters. It is a complete actuator assembly incorporating two motors, 1/10 hp and 3.3 hp, operating through gear reductions to give a drive rate of 6/100" per second and 7/10" per second respectively to the screw jack. Normal operating load is 11,000 lbs.; static load is 80,000 lbs. The small motor operates almost continuously with automatic pilot, while the larger motor provides for manual pilot control at a higher rate of maneuvering. Type R-129 operates on a 28 volt DC system, has overload and limit switches, radio noise filter, position indicator, non-jamming stops. Weight, 45 lbs.

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ant desirability as an aircraft-structural material, and problems involved in forming, machining, and welding operations. As a group, the panel made a strong point when they said, in effect, that while the present state of the art permitted titanium to be employed wherever necessary, development work was needed to improve forming, machining, and welding techniques in order to improve its economic positions with regard to competitive materials.

An audience of approximately 75 members and their guests thoroughly appreciated the informative manner in which the subject was presented. Extensive audience participation developed during the question-answer period and over coffee and doughnuts which were served at the close of the meeting.

Washington Section

T. C. Muse, *Secretary*

Members of the Washington Section were the guests of the David Taylor Model Basin, Carderock, Md., for the meeting on March 2. After an excellent dinner at the cafeteria, the group examined the new "ALWAC" data-reduction computer in the control room of the transonic wind tunnel. The "ALWAC" will be used primarily for reduction of the wind-tunnel test data, but it had been set up for the visit to answer popular questions and do mental gymnastics which would demonstrate its versatility. So without resorting to tedious problems, the visitors were properly impressed and entertained at the same time.

Following the "ALWAC" demonstration, the manual analog computer "MAC," used to reduce strain-gage balance data of the 7- by 10-ft. subsonic wind tunnel, was examined. For those of the visitors who had struggled through the early days of strain-gage balances with manual computations, it was evidence of real progress in wind-tunnel operations.

The meeting was opened by the Chairman, Capt. W. C. Fortune, USN, who is also the Aerodynamics Officer at the DTMB. He introduced R. T. Patterson, Head, Supersonic Branch of the High Speed Division, Aerodynamics Laboratory, and Dr. O. E. Lanchaster, Assistant Director of the Research Division, who had arranged the meeting.

Following this, the nominees for Section Officers for 1954–1955 who were present were introduced. These were Dr. F. N. Frenkiel, APL, and Brig. Gen. B. S. Kelsey, USAF, for Chairman; Herb Goda for Vice-Chairman; and Maj. Gen. J. F. Phillips, USAF (Retired), AIA, for the Advisory Board.

Captain Fortune then introduced Capt. Albert G. Mumma, USN, Commanding Officer and Director, DTMB, who extended greetings and welcomed the visitors aboard.

Dr. Charles V. L. Smith, ONR, presiding Chairman of the meeting, described briefly the history and background of the automatic computing machines. He stated that in the short time period of approximately 8 years the field had grown from one of a very few machines to the present stage where their use is industry-wide and future developments are almost without bounds.

Dr. Franklin Myers, of The Glenn L. Martin Company, then gave a talk on "Applications of Computer Equipment at The Glenn L. Martin Company." Dr. Myers stated that at Martin the computing laboratory serves as a service division for the entire company. In the field of aerodynamics, a great deal of the Martin company's wind-tunnel testing is done at the University of Maryland. There, the experimental data comes out on punched cards which are simply taken to the plant and then automatically processed. The computing laboratory does considerable work in the investigation of missile flights by simulation and, as a result, has been able to reduce flight failures and delays between flights to a minimum.

Dr. Samuel Levy, of the National Bureau of Standards, the second speaker of the evening, gave a talk entitled "The Use of High-Speed Digital Computing Machines on Some Aircraft Structural Problems." He stated that the main characteristics of an electronic computer were the ability to make extremely high-speed calculations and the capacity for a large memory storage. These characteristics made it desirable to use the machine for problems involving a great deal of repetition, where at least 100,000 calculations are required or where quick answers of detailed formula are needed. Dr. Levy demonstrated by simple examples the coding of information for the machine and then went through the general procedure of a structural problem for a delta-wing aircraft.

The final feature of the program was a demonstration by Dr. Henry Polachek and staff of the UNIVAC computer of the DTMB Applied Mathematics Laboratory. As an example, they had the machine make a 36-point pressure distribution calculation for an airfoil. The machine required about 20 secs. for the calculation. The equivalent manual time would be something like 2 days. Dr. Polachek stated that the UNIVAC machine has been in use for approximately 6 months during which it has been used on all types of calculations made at the Basin. Its operating efficiency had been around 82 per cent. In 1 week, during which it was used for approximately 115–120 hrs., the delay due to breakdown attributable to the machine was only 15 min.

Student Branches

Agricultural & Mechanical College of Texas

Grover L. Alexander, *Secretary*

The fourth meeting of the Texas A. & M. IAS Branch was held on April 6. Papers to be read at the Texas Section's Annual Paper Competition at Dallas were presented to the 28 members present.

Ted C. Nark, Jr., a senior Aeronautical Engineering student and Representative of the Undergraduate Division, presented a paper on creep of metals and its effect on aeronautical structures. He explained that this phenomenon has become prominent in aircraft only since the development of jets, etc., which must operate under high temperatures and stresses. Creep, he stated, is affected by the structure of the material; fine-grained material is more creep resistant at low temperature, while coarse grained is more creep resistant at high temperatures. Mr. Nark suggested alloys as the answer to the problems created by creep and named specifically magnesium and manganese alloys, with other combinations of such "freak" metals as molybdenum. After Mr. Nark's presentation, Chairman Dan Palmer collected the criticisms from the group.

Miss Joyce Pritchett, a Sophomore from Texas University was chosen by the members to represent the Branch as a Duchess at the Annual Cotton Ball. Dick B. Hull will be her escort.

Mother's Day activities were then discussed and plans were left to the Combined Exhibit Committee and to the Main Building Committee. Dick Hull was selected Chairman for the Combined Exhibit Committee, and the entire group of senior students, plus Paul Meiners and Grover Alexander, were charged with the duties of the Main Building Committee.

Plans for the spring Bar-B-Q on May 4 were then made, and the following Committee Heads were appointed: James Barnard, tickets; Bennie Heathman, location; and Charlie Anderson, food.

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Dan Palmer, Chairman and Paper Competition Representative of the Graduate Division, then presented his paper on shielding of nuclear aircraft. Weight, he said, is one of the main problems, with size ranking next. Not only must the crew be shielded, but so must the ground personnel and vital parts of the plane itself. As a result, he said, a combination of power-plant shielding and personnel and vital-part shielding will probably be used. Since no one material is best for all kinds of radiation, Mr. Palmer suggested a shield of layers of different materials, such as lead, carbon, and various liquids. He said that thermal, as well as radiation, shielding would be necessary. After criticism and comment, the meeting was adjourned.

The Catholic University of America

Robert E. Kastner, *Secretary*

On Wednesday evening, March 10, The Catholic University of America Student Branch of the IAS held its fourth monthly meeting of the year.

Chairman William Elsen introduced the speaker of the evening, Terry Clark, Washington Representative, McDonnell Aircraft Corporation. Speaking on the organization of an engineering company, Mr. Clark put forth the question, "What constitutes an engineering company?" He described the organizational make-up of McDonnell, as an example for the members present. The speaker devoted the major part of his talk to the engineering section of the company. He outlined and explained in detail the functions of each section, as well as the duties and problems that an engineer just out of college might expect to encounter in each particular section. Mr. Clark emphasized the fact that a new engineer should not become too specialized. Rather, he should not be afraid to accept positions in different sections, because this will give the experience in diverse fields necessary for advancement.

After his talk, Mr. Clark showed a film, *Little Henry*. This film is concerned with the development and experimentation by McDonnell of a ramjet helicopter, the first successful one of its kind.

Indiana Technical College

Harold R. Woodhouse, *Secretary*

The March 16 meeting was called to order by the newly elected Chairman, Harold Coffman. During a business session, it was decided that a field trip would be made on April 23 to North American Aviation's plant in Columbus, Ohio.

The meeting was concluded by the showing of a film, *Flying Action*.

One of the speakers before the U.S. Naval Postgraduate School Student Branch of the IAS during the 1953–1954 academic year was Major Gen. Albert O. Boyd, USAF, Commanding General, Wright Air Development Center. General Boyd (center) is flanked on his right by Comdr. R. W. Arndt, USN, Officer in Charge, Aeronautical Engineering, U.S. Naval Postgraduate School, and on his left by Dr. Wendell M. Coates, Professor and Chairman, Department of Aeronautics, U.S. Naval Postgraduate School.

U.S. Naval Postgraduate School

George R. Kelly, *Secretary*

The U.S. Naval Postgraduate School Student Branch of the IAS has been fortunate this year in obtaining several well-known and well-qualified speakers for the monthly meetings. Since last October, the research segment of the aircraft industry and the industry itself have been represented, as have the flight test and evaluation groups of the industry and the Air Force.

The rundown of topics goes something like this: large liquid-fuel rocket-propulsion systems; present-day and drawing-board ram-jet engines and their applications in aircraft and missiles; engineering flight testing as carried on in the industry; and the flight test and evaluation of foreign aircraft as conducted by the USAF.

Leading off the series was Dr. Walther Riedel, of North American Aviation, Inc. Dr. Riedel was Chief Engineer on the German V-2 rocket project during World War II and has been active in the large rocket field for several years. The meeting was opened to the wives and guests of the members at the Postgraduate School, and the attendance was 350.

The next speaker was Roy E. Marquardt, President of Marquardt Aircraft Company, who is one of the pioneers in the development of the ramjet engine. Mr. Marquardt discussed current and future ram-jet engines and their applications in missiles and aircraft. The discussion was classified, and the attendance was limited to members. Fifty members were present.

Dr. W. L. Howland, of Lockheed Aircraft Corporation, was the speaker at the following meeting. His subject was "Engineering Flight Test and Evaluation." Dr. Howland discussed procedures and techniques that have been evolved in the industry in general and at Lockheed in particular. Fifty members attended.

The last speaker was Major. Gen. Albert O. Boyd, USAF, Commanding General, Wright Air Development Center. General Boyd presented a classified evaluation of the Russian MIG-15 from a research and development point of view. Attendance was limited to members and specified guests at the Postgraduate School. One hundred and fifty were present.

Current plans are to have Harold Luskin, of Douglas Aircraft Company, Inc., speak at the April 14 meeting on the general subject of "Characteristics of Supersonic Aircraft" and in particular on the design of the latest research airplane built by Douglas and now flying at Edwards AFB, Calif.

The Student Branch has arranged for Dr. Clark Millikan, of California Institute of Technology, to speak at the meeting in May, which will be the final one of the 1953–1954 school year.

University of Tulsa

Donald S. Boyd,
Secretary-Treasurer

The February 25 meeting was called to order by Chairman Jack Owens at 7:30 p.m. The total attendance was 15.

Chairman Owens introduced the speaker of the evening, Stan Morton, Staff Engineer from Boeing Airplane Company's Personnel Department. Before Mr. Morton began his talk, a film, *Boeing Presents*, was shown. This film described the various phases of an engineer's work and the living conditions in Wichita and Seattle. Mr. Morton then discussed in greater detail the operations of the engineering staff and some of the projects now under way at Boeing. Personal questions were answered, concerning working procedures, benefit policies, and general living conditions in both Wichita and Seattle.

During the meeting, an election was held for the office of Secretary-Treasurer; Donald Boyd received the position.

The meeting was adjourned at 10:30 p.m.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Nichols, Mark R., B.S. in Ae.E. & B.S. in M.E., Asst. to Div. Chief for Special Projects, Full Scale Research Div., NACA, Langley Aero. Lab.

Schlichting, Hermann, Ph.D., Dir., Inst. of Fluid Mechanics & Prof., Technical University of Braunschweig (Germany).

Wainwright, George C., B.S., S/L., Tech. Br., RAF, Hq., USAF.

Transferred to Associate Fellow Grade

Fogarty, Laurence E., Ph.D., Head, Aerodynamics, Link Aviation, Inc.

Graff, George S., B.S. in Ae.E., Member, NACA Subcommittee on Stability & Control; Chief of Aerodynamics, McDonnell Aircraft Corp.; Member, Parks College Industry Committee.

McDanial, Keith K., Field Dir., Boeing Airplane Co.

Elected to MEMBER Grade

Anderson, James E., M.S.Eng. Design, Computing Engineer, Douglas Aircraft Co., Inc. (El Segundo).

Barkalow, Clare E., M.A. (Physics), V-P—Gyromechanisms, Inc.

Barlow, William H., B.Ae.E., Sr. Aerodynamic Engineer, Propeller Div., Curtiss-Wright Corp.

Beam, Benjamin H., B.S.E.E., Aero. Research Scientist, NACA, Ames Aero. Lab.

Boyd, William E., B.S.E.E., Col., USAF., Sr. Pilot & Deputy Comdr., 11th Air Div., Dept. of Defense.

Bridgforth, Robert M., Jr., S.M. (Physical Chemistry), Research Engineer "A," Boeing Airplane Company (Seattle).

Callaway, Daniel B., B.S., Mgr., Western District, Industrial Sound Control, Inc.

Christensen, Horace H., B.S.M.E. (Aero.), Devel. Engr., A. & O.S. Dept., General Electric Co.

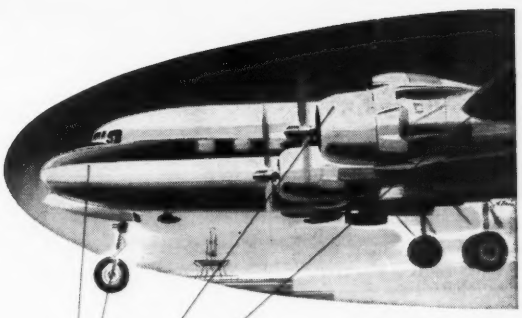
Doyle, Lee J., Proj. Engineer, Industrial Sound Control, Inc.

Elbaum, Max C., Chief Engineer, Atlantic-European Div., Transocean Air Lines.

Frohoff, William H., Jr., B.S. in Ae.E., Struct. Test Engineer, North American Aviation, Inc. (Columbus).

Fuchs, Abraham M., S.M.E.E., Sr. Engineer, Air Arm Div., Westinghouse Electric Corp.

Gold, Theodore, B.S.M.E., Engineering Section Head, Sperry Gyroscope Co. Div., The Sperry Corp.



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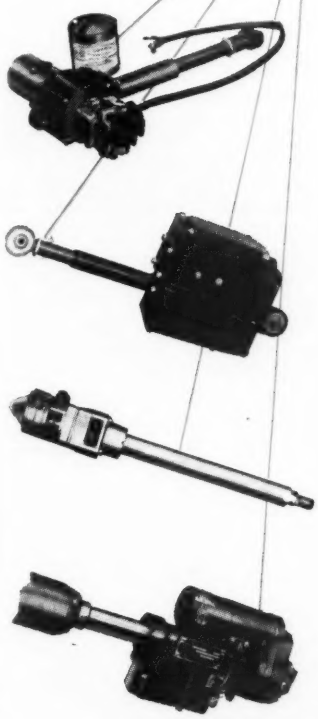

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Goode, Archie E., B.S.E.E., Sr. Aircraft Designer, Lockheed Aircraft Corp. (Georgia).

Hodges, Robert H., B.S. Industrial Administration (including Aerodynamics), Patent Engineer, Sikorsky Aircraft Div., United Aircraft Corp.

Horner, Richard E., M.Sc. (Engineering), Tech. Dir., Air Force Flight Test Center, USAF, Edwards AFB.

Johnson, William F., Jr., M.S., Proj. Engineer—Research, Curtiss-Wright Corp.

Keetch, William A., B.S. in M.E., V-P—Engrg., Robinson Aviation, Inc.

Kvass, T. Arthur, M.A. (Physics), Staff Asst., Missile Design, Douglas Aircraft Co., Inc. (Santa Monica).

Lackman, Gerald L., B.Sc. (M.E.), Engineer "A," Heat & Vent Group, Canadair, Ltd.

Nelson, Norman E., B.S.A.E. & A.E., Chief Engineer, Doak Aircraft Co., Inc.

O'Meara, Francis E., B.S., Sr. Physicist, Operations Analysis, Strategic Air Command (Omaha, Neb.).

Rogers, W. C., B.S.M.E., Test Engineer, Aeroproducts Operations, Allison Div., General Motors Corp.

Ruptash, John, Ph.D.Ae.E., Assoc. Prof. of Aero. Engineering, Univ. of Wichita.

Schwab, George H., Jr., Producibility Engineer, Ryan Aeronautical Co.

Smith, John C., B.S.E.E., Sr. Design Engineer, Fairchild Engine Div., Fairchild Engine & Airplane Corp.

Sommer, Arthur V., B.M.E., Asst. Section Head, Gyroscopics Section, Research & Devel. Dept., Arma Corp.

Sorace, Kenneth J., E.E., Chief Proj. Engineer, Lamson & Sessions Co.

Speas, Charles A., B.S.M.E., New Products Engineer, Sun Tube Corp.

Webb, William C., B.S.C.E., Sr. Design Engineer, Chance Vought Aircraft, Inc. (Dallas).

Williford, E. Allan, B.S. in E.E., President & Dir., Link Aviation, Inc.

Wright, George T., B.S. Industrial Engineering, Manufacturers Rep., self-employed.

Transferred to MEMBER Grade

Carner, Harold A., B. of Ae.E., Sr. Flight Test Engineer, Republic Aviation Corp.

Faber, Stanley, B.S. in M.E. (Aero.), Aero. Research Scientist, III, Stability & Control Branch, Flight Research Div., NACA, Langley Field.

Perrin, Louis A., B.S. in Ae.E., Sr. Design Engineer (Armament), McDonnell Aircraft Corp.

Priest, Roy R., B.S. in Ae.E., Sr. Design Engineer, McDonnell Aircraft Corp.

Roberts, William F., B. of Ae.E., Stress Engineer, Northrop Aircraft, Inc.

Elected to Associate Member Grade

Adamson, Louis S., Spareparts Sales Mgr., Canadair, Ltd.

Moriarty, John L., Operations Supervisor (Air Route), CAA.

Perie, Johan H., Dipl. Chem. Engrg., Naval Aviator, Lt. Comdr., Asst. Naval Attaché for Air to the Netherlands Embassy-Bureau of Naval Attaché, Netherlands Embassy, Netherlands Navy (Washington, D. C.).

Ridenour, P. J., Jr., Standards Engineer-Supervisor, Temco Aircraft Corp.

Elected to Technical Member Grade

Athens, Peter B., S.B. in C.E., Engineer, Allied Research Associates, Inc.

Cardillicchio, Paul A., B.A., Chief Designer, Industrial Sound Control, Inc.

Clanton, Ronald G., Engineer, Analytical Group, Air Arm Div., Westinghouse Electric Corp.

Colyer, D. B., B.S.Ae.E., Engineer, Sverdrup & Parcel, Inc.

Egan, Thomas W., Jr., B.S. in Ae.E., Aerodynamicist, Bell Aircraft Corp.

Katz, Donald J., B.S.Ae.E., Flight Test Analyst "A," Northrop Aircraft, Inc.

Kourbelas, Nicholas S., B.S.M.E. (Aero.), Struct. Engineer, Convair (San Diego).

Leyds, J., M.S., Aerodynamicist "A," A. V. Roe Canada, Ltd. (Malton).

Macdonald, James C., B. of Ae.E., Material Review Engineer, Republic Aviation Corp.

Mediatore, Richard, B.S.C. (Mech.), Engineer, Chance Vought Aircraft, Inc.

Palmer, David A., Liaison Engineer, Kaman Aircraft Co.

Pray, Donald G., Technical Analyst, Convair (Ft. Worth).

Rodriguez, Jose A., Jr., Aero. Engineer (Tech.), Republic Aviation Corp.

Russell, Robert W., Engineer, Univ. of Southern California Engrg. Center.

Simon, William E., B.S.Ae.E., Aerodynamics Engineer, Convair (Ft. Worth).

Singer, Irvin, B.C.E., Principal Struct. Engineer & Group Leader, Republic Aviation Corp.

Van Artsdalen, Charles M., B.S.Ae.E., Model Designer, Chance Vought Aircraft, Inc.

Walker, Francis J., Jr., Engineering Asst., Jet Propulsion Lab., California Inst. of Technology.

Yon, Terrell H., Jr., B. of Ae.E., Assoc. Aircraft Engineer, Lockheed Aircraft Corp.

Transferred to Technical Member Grade

Albrecht, Richard L., Jr. Engineer-Draftsman "A," Northrop Aircraft, Inc.

Blase, Eugene P., B.S.—Aero., Design Engineer, Helicopter Div., McDonnell Aircraft Corp.

Castner, Theodore G., Jr., B. of Engrg. Physics, Grad. Teaching Asst., Physics Dept., Univ. of Illinois.

Chambers, Edward A., B.S. in Ae.E., Prelim. Design Aerodynamicist, North American Aviation, Inc. (Columbus).

Chapin, Glenn A., B. of Ae.E., Rocket Component Test Engineer, Bell Aircraft Corp.

Davies, Robert S., B. of Ae.E., Research Engineer—Aerodynamics, Grumman Aircraft Engineering Corp.

Falk, Theodore J., B. of Ae.E., Engineer, Subsonic Aerodynamics Group, Research Dept., United Aircraft Corp.

Gentles, Ralph L., Struct. Engineer, North American Aviation, Inc. (Columbus).

Gionfriddo, Maurice P., B.S. in Ae.E., Aero. Engineer, 6520th Test Support Wing, L. G. Hanscom Fld, Cambridge Research Center.

Gossett, William M., Jr. Engineer, Convair (San Diego).

Gray, Irving E., B.S. Jr. Engineer, Production Liaison Group, Design Operations Section, Chance Vought Aircraft, Inc.

Gregorwicz, Peter P., Design Draftsman, Devel. Lab., Bendix Aviation Corp.

Kennedy, Edward R., B.E., Aero. Engineer-Thermodynamicist, North American Aviation, Inc. (Columbus).

Kozlowski, Andrew J., Draftsman Diesel Equip. Div., General Motors Corp

Kulachkosky, John.

Lane, John H., B. of Ae.E., 2nd Lt., USAF; Grad. Student, USAF Inst. of Technology, Wright-Patterson AFB.

Laraway, William D., B.S. in Ae.E., Designer, Scintilla Div., Bendix Aviation Corp.

Lipschutz, Maxwell J., B.S. in Ae.E., Sr. Research Engineer, Power Plant Group, Republic Aviation Corp.

Malakoff, James L., B. of Ae.E.

Mirels, Harold, Ph.D., Aero. Research Scientist, NACA (Cleveland).

Muir, Thomas G., B.S.

Ortell, Alexander R., Pvt., USA (Camp Pickett, Va.).

Putnam, V. Keith, B.S., Proj. Engineer, Flight Research Branch, Rotary Wing Section, USAF, Air Force Flight Test Center, Edwards AFB.

Roth, Gerald M., B.S. in Ae.E., Power Plant Engineer, The Glenn L. Martin Co.

Sloan, Richard H., Jr. Engineer-Draftsman "A," Northrop Aircraft, Inc.

Smith, Marvin A., B.S., 2nd Lt., USAF.

Thievon, William J., B.S. in Ae.E., Engineering Trainee, Performance Group, Aerodynamics Dept., Republic Aviation Corp.

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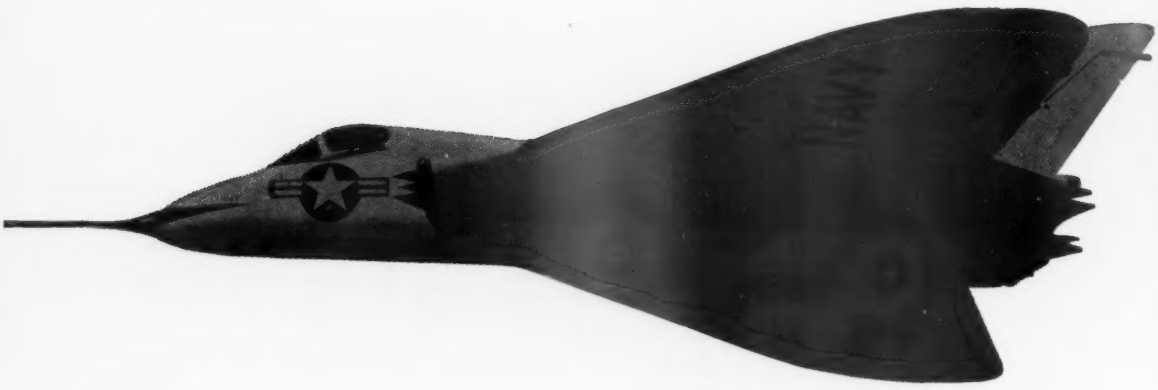

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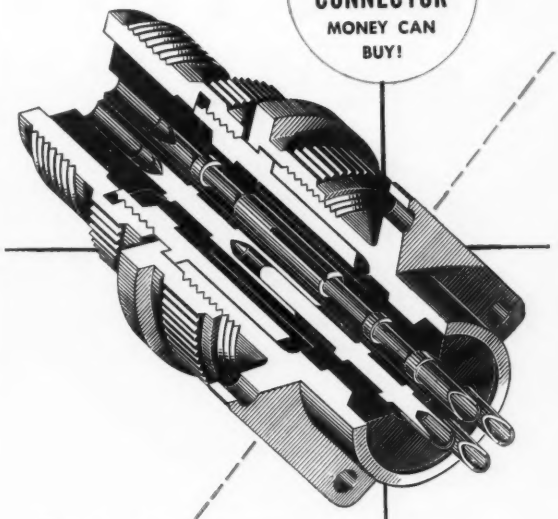

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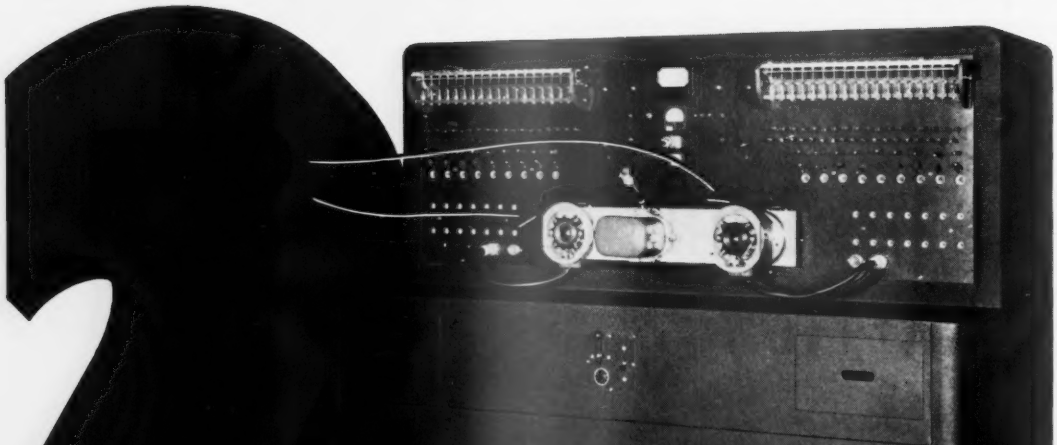

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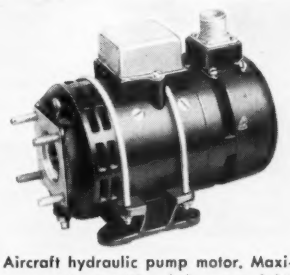

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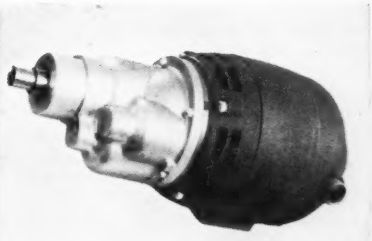

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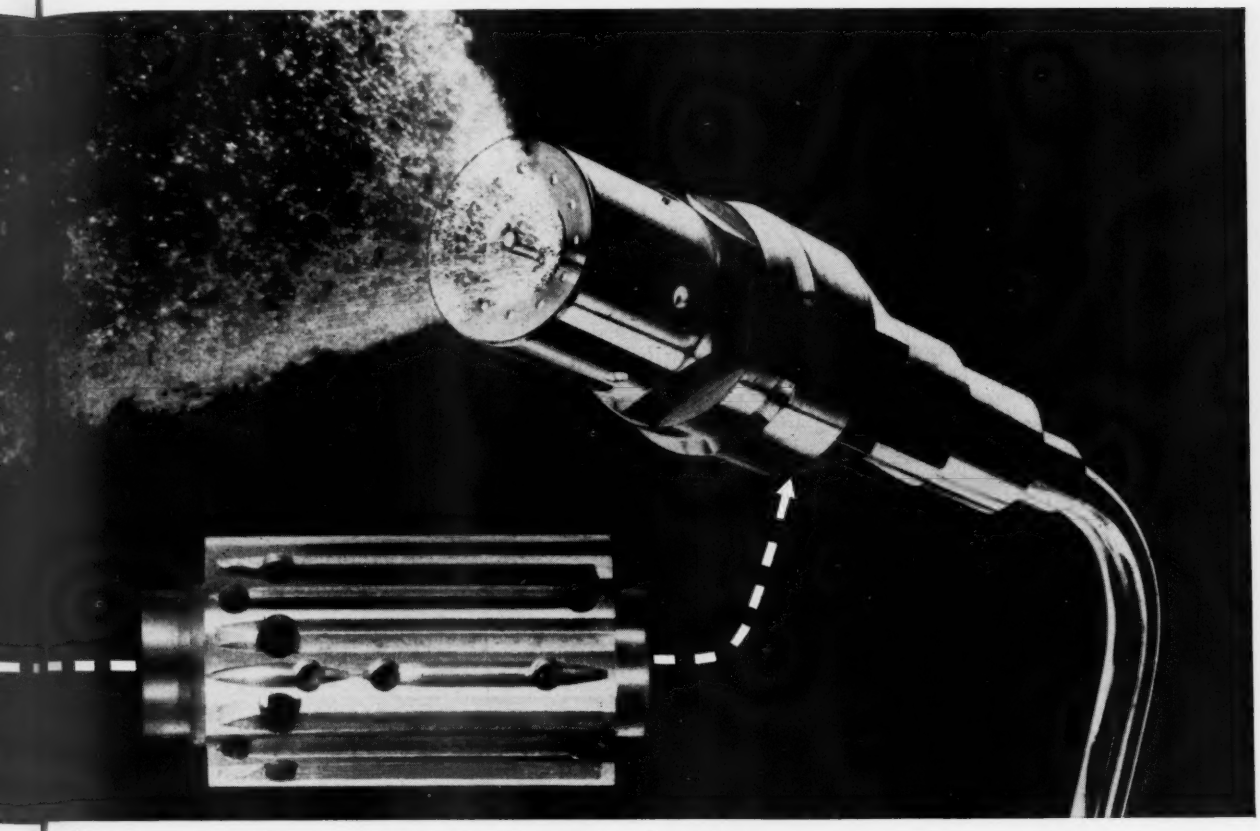

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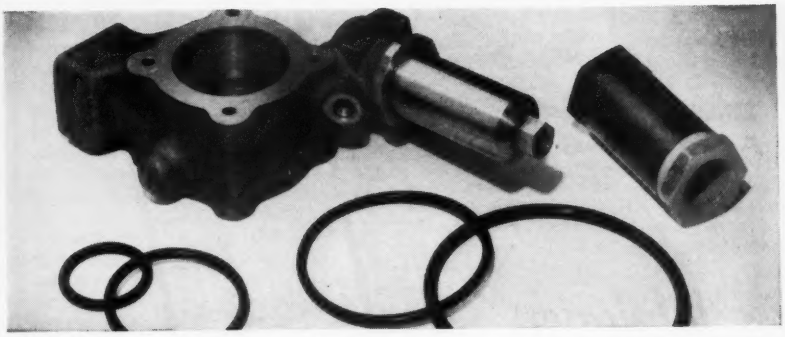

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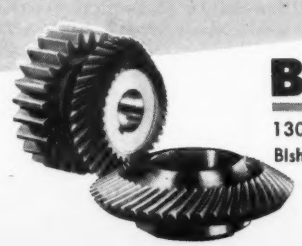

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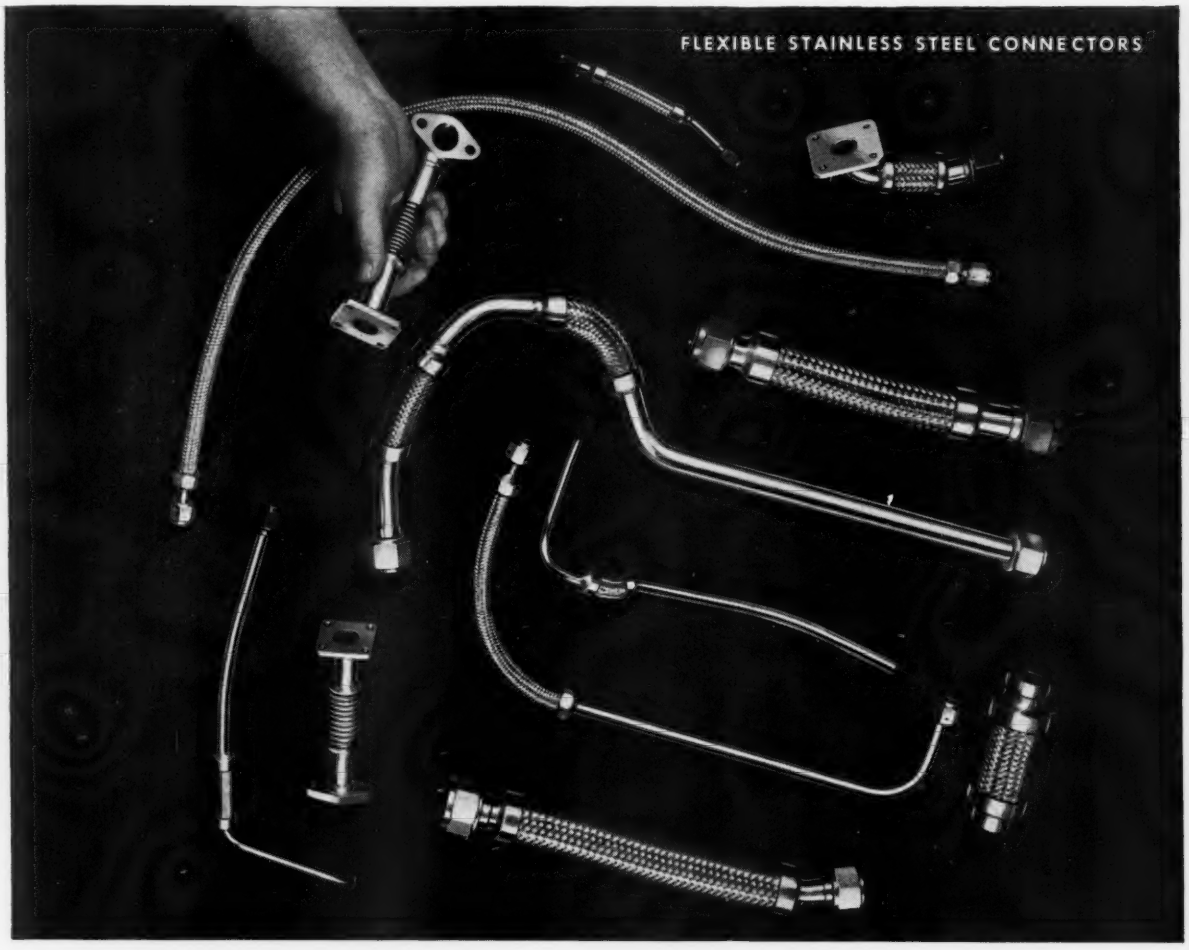

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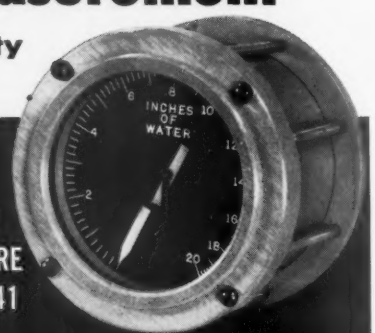

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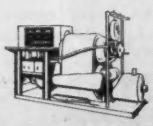

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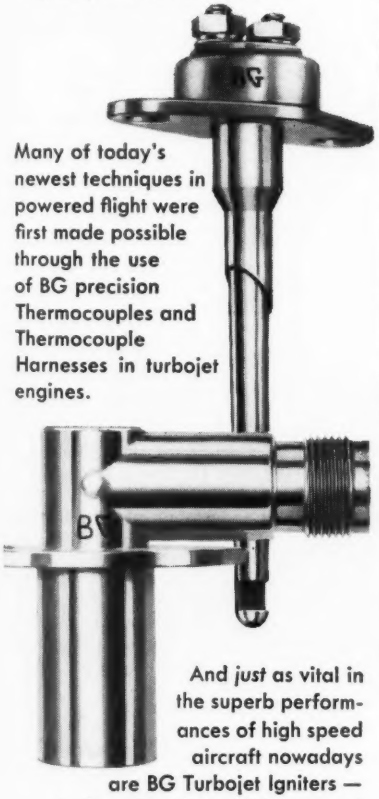

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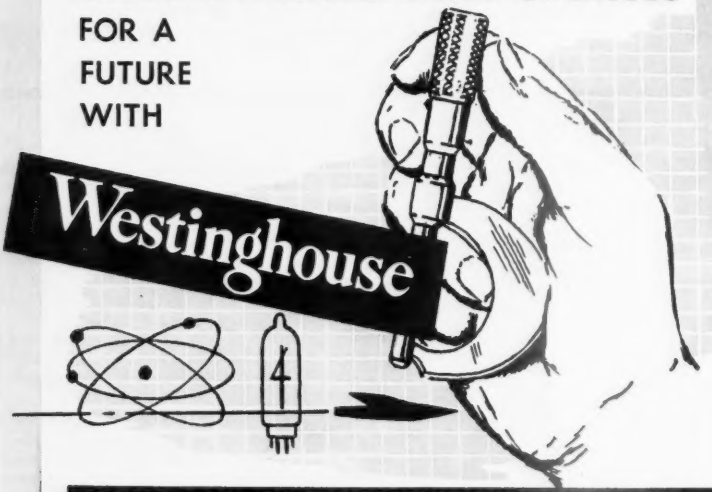

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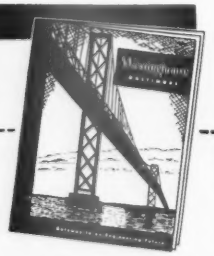

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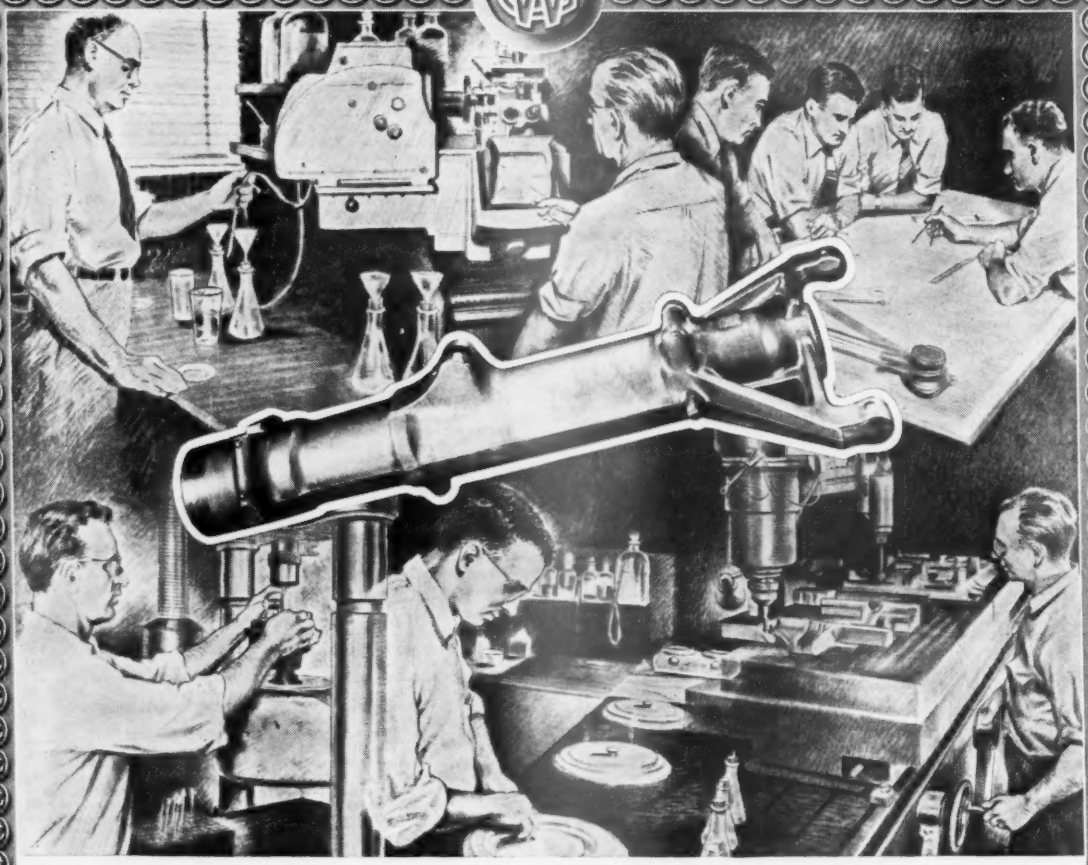

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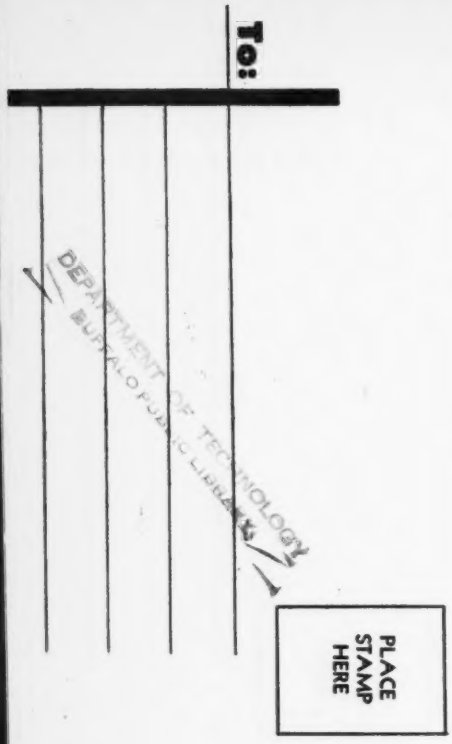

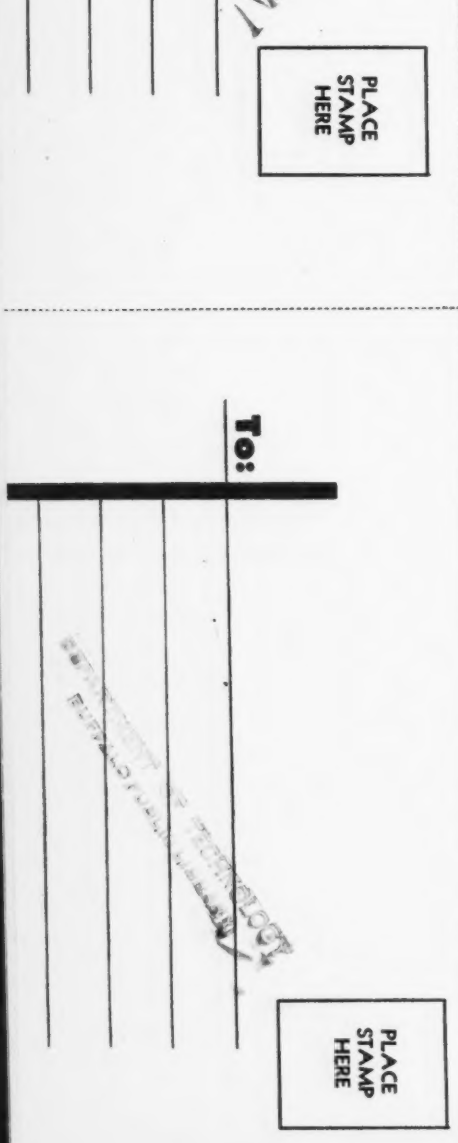

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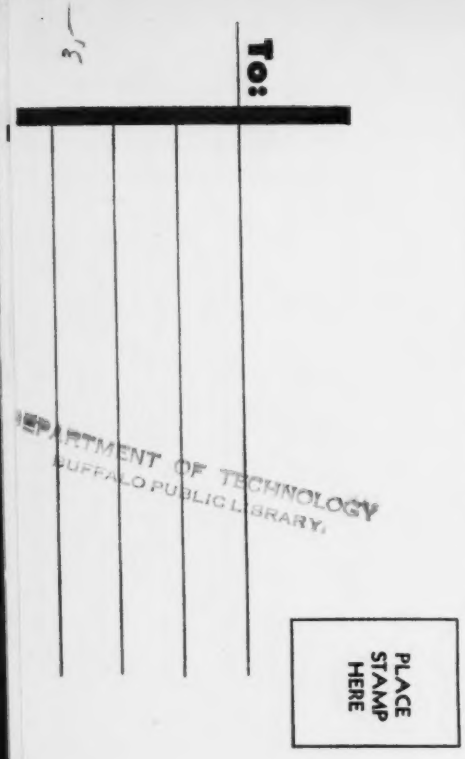

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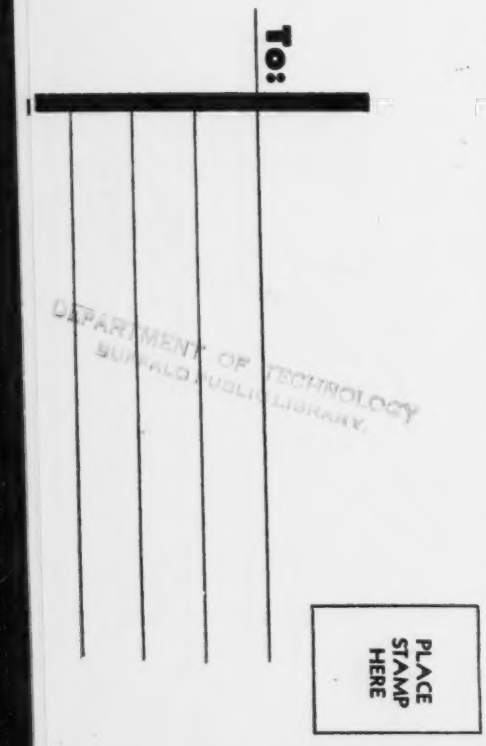

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RESEARCH & TEST EQUIPMENT

K-Band Test Horns. Developed in a series covering the frequency range from 12,400 to 40,000 megacycles, for use in radar and microwave testing procedures. **Airtron, Inc., Dept. A, Linden, N.J.**

24- by 24-In. Altitude Test Chamber. This transparent unit permits continuous observation of the object being tested. **American Research Corp., Bristol, Conn.**

"Jetcal Tester." Tests temperature measuring systems of jet engines, aircraft overheat detectors, and anti-ice devices, without running the engine or disconnecting any wiring. **B & H Instrument Co., Inc., 1009 Norwood, Fort Worth, Tex.**

Portable Comparator. For calibrating extensometers, compressometers, dial gages, and similar instruments. Bulletin No. 4210. **Baldwin-Lima Hamilton Corp., Philadelphia 42, Pa.**

Metagraphic System. A three-part pneumatically operated instrument system for measuring, indicating, recording, and controlling pressure, vacuum, temperature, liquid level, differential pressure, and flow. **The Bristol Co., Waterbury 20, Conn.**

Sub-Zero Test Unit ST-120. Automatically cycles test parts through alternate hot and cold temperatures. **Cincinnati Sub-Zero Products Co., 3932 Reading Rd., Cincinnati 29, Ohio.**

Type 106 Miniature Sine-Cosine Potentiometer. This 1-oz. unit will operate on either a.c. or d.c. current without booster or compensating amplifiers. **Computer Instruments Co., 1964 Utica Ave., Brooklyn 34, N.Y.**

Norwood Controls 5AC Pressure Monitor. Designed to give calibrated readings of any dynamic pressure. **Control Engineering Corp., Norwood, Mass.**

Series 690 "Plug-In" Attenuation Networks. The "plug-in" feature permits input and output impedance to be changed to any value by substituting "plug-in" pads of the particular impedance desired. **Daven Co., Dept. SX, 191 Central Ave., Newark, N.J.**

Model 10 Laboratory Oscillator. This unit gives continuous coverage over a frequency range from 1.8 cycles per sec. to 2.2 megacycles per sec. in six overlapping decades. **Donner Scientific Co., 2829 Seventh St., Berkeley 10, Calif.**

"Singleton" Salt-Spray Test Cabinet. Completely transparent, this cabinet affords clear visibility for observing and controlling progress of tests. **The G. S. Equipment Co., 5317 St. Clair Ave., Cleveland 3, Ohio.**

AK-5 Hook-on Volt-Ammeter. This pocket-size unit features an automatic scale changer. **General Electric Co., Schenectady 5, N.Y.**

Technique in Fluorescent Penetrant Inspection. "Zyglo-Pentrex" method locates both very tight cracks and broad, shallow defects. **Magnaflux Corp., 7300 W. Lawrence Ave., Chicago 31, Ill.**

Bennett Gas Volume Meter. Measures the volume of any gas passed through it. **J. J. Monaghan Co., Inc., 500 Alcott St., Denver, Colo.**

Telemeter Packages. Incorporates plug-in subcarrier oscillators which, when used with power supply and RF transmitter, provide a compact FM/FM system for telemetering many functions. **Pacific Div., Bendix Aviation Corp., 11600 Sherman Way, North Hollywood, Calif.**

PL 1004 Multimeter. Tests various elements of electronic and electrical circuits. **Phaostron Co., 151 Pasadena Ave., South Pasadena, Calif.**

Model 432 Interval Timer. For measuring short time intervals. **Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N.Y.**

Measuring, Indicating, Recording, & Controlling Devices. Eight-page folder describes aircraft research instruments. **Schaevitz Engineering, P.O. Box 505, Camden 1, N.J.**

Model C-6 Resistance Meter. A combined ohmeter and leakage tester. **Southwestern Industrial Electronics Co., 2831 Post Oak Rd., P.O. Box 13058, Houston 19, Tex.**

Digitester 48A. Measures resistance, voltage, and current and supplies a direct-reading digital output. **Telecomputing Corp., 133 E. Santa Anita Ave., Burbank, Calif.**

Model 521-A Peak-Reading Accelerometer. The "Carometer" reads the largest acceleration received by the pickup head and holds this reading up to 2 hours or until reset to zero. **Victoreen Instrument Co., 3800 Perkins Ave., Cleveland 14, Ohio.**